



THE STATES AND NATURAL HAZARDS

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The Council of State Governments

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The States and Natural Hazards

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Foreword

Despite the known threat of natural hazards, few persons and communities rate them high among the issues which need to get high-priority consideration from their state and local governments. Although a number of these hazards are of great concern to some, many Americans still think that they are something that should be taken in stride.

On the other hand, every year Americans experience numerous problems brought on by hundreds of natural disasters. Many persons are killed or injured. Losses due to damage from disasters and funds expended for post-disaster assistance and rehabilitation run into the billions. The amount of such losses and the accompanying human suffering have increased greatly and can rise to even higher levels as urban concentration increases, as the stability of the environment becomes more critical, and as marginal lands and structures are utilized, often without desired protection, by larger numbers of people, especially the elderly and disadvantaged.

Through this publication, the Council of State Governments seeks to acquaint state officials with new federal policies designed to place greater emphasis on mitigating the risks and reducing the costs of natural hazards. The report identifies basic elements and issues significant to the assessment and development of effective programs by state and local governments dealing with natural hazards.

Lexington, Kentucky
July 1979

William J. Page, Jr.
Executive Director
The Council of State Governments

Preface

This report is the second of two publications on natural hazards produced by the Council of State Governments in a two-year project financed by the National Science Foundation.

As the project was first proposed, it was aimed primarily at identifying the public policy issues which state governments may need to face as the science of earthquake prediction makes anticipated advances. This was an objective of a national conference held by the Council in November 1977, which led to the first project report published by the Council late in 1978 (National Conference on Earthquakes and Related Hazards) and disseminated widely to state officials and others throughout the United States.

After funds for the project were first made available early in 1977, two developments occurred in the federal government's approach to natural and other hazards which had a significant impact on the Council's project. The president proposed and Congress approved the creation of a new Federal Emergency Management Agency concerned with mitigation, response, and recovery efforts for a wide variety of natural and man-made hazards. Plans for the new agency are now being implemented by presidential action and the agency's new leadership. In addition, Congress enacted new legislation on earthquake hazard reduction, mandating the development by the federal government of plans to implement earthquake hazard reduction measures at federal, state, and local levels of government.

These new federal developments, as well as views expressed by three committees of state officials established to assist in the Council's project—composed of state attorneys general, planners, and emergency services directors—by scientists, and by program administrators from federal agencies and academic institutions, led the Council to broaden its approach beyond earthquakes to natural hazards in general. Not only was there more interest in this approach by a greater number of states, but many knowledgeable hazards specialists advised that the mitigation of earthquake hazards would more likely benefit as part of hazard reduction efforts aimed at natural and possibly even a broader range of man-made and other hazards. Many of the same or similar policy and administrative problems were seen to have general application.

This report is a product of a Council staff effort headed by Hirst Sutton, project director. Robert D. Kuzelka assisted him in project studies and in developing this report. Consultants Charles M. Manning and James L. Huffman, both attorneys, participated in matters involving legislative and legal liability issues. An advisory council whose members had extensive experience in various aspects of the project's considerations consulted with the project staff and reviewed this report. The three committees of state officials identified above

contributed greatly to the development of project content and recommendations as did representatives from federal agencies, public interest bodies, and research organizations. The Council welcomed the opportunity for a positive interrelationship with the National Governors' Association's 1978 emergency preparedness project, also in progress during the course of much of the Council's undertaking. Council staff Margaret Schrader and Emily Adams assisted in preparing material for this publication, and Ralph J. Marcelli edited this report.

H. Milton Patton
Associate Director for Environmental Resources

1. Introduction and Executive Summary

INTRODUCTION

Natural hazards such as earthquakes, tornadoes, droughts, and floods are responsible for the expenditure of billions of dollars and a great deal of human suffering. The impact of these hazards can be lessened through effective government programs aimed at comprehensive emergency management. This approach requires assessing natural hazards and addressing the issues of reducing the dangers and costs of natural hazards through hazard mitigation, disaster response, and post-disaster recovery.

Public interest groups, professional associations, and public administrators recognize that natural hazards occur frequently and have not always been given adequate policy and management attention, especially in terms of readiness to respond effectively when crises occur, in developing cost-effective and hazard-reducing measures, and in implementing recovery programs that reduce or eliminate risks from future hazardous events. They are also aware that natural hazards present much greater risks as population density increases in critical areas.

Recent federal actions reflect new attitudes toward comprehensive emergency management. The establishment of a new federal agency in 1979, the Federal Emergency Management Agency, brings together a number of functions formerly in several different departments and identifies a broadened federal disaster role encompassing mitigation and recovery measures as well as preparedness for and actual response to emergencies when they occur. In addition, the enactment of the Earthquake Hazards Reduction Act of 1977 and development by the executive branch in 1977-78 of a National Earthquake Hazards Reduction Program in implementation of the act emphasize that state and local governments and the private sector have significant responsibility for hazard reduction action.

Thus a new setting for programs which deal comprehensively with hazard mitigation, disaster response, and post-disaster recovery has been effected by recent federal actions. These actions offer the opportunity for more effective and comprehensive emergency management at all levels of government, with the expectation of even greater leadership from the federal government.

It is timely, therefore, that states and communities assess their roles and responsibilities for strengthening their programs in a way that enhances public safety and well being and reduces economic losses. This report seeks to point out ways in which more effective and comprehensive natural hazard programs can be attained.

Although the focus of this report is on natural hazards, a comprehensive emergency management effort could also include emergencies brought about by

man-made and technological hazards and by enemy attack (civil defense). For example, the Three Mile Island nuclear power plant incident resulted in evacuation procedures similar to those that might be required in the event of a natural disaster. However, whether a state chooses to have an individual program for special attention to certain hazards, or a comprehensive program for all natural hazards, or an all-hazards comprehensive program, this report should prove valuable. It points out ways in which more effective natural hazards programs can be developed by state and local government, ways which are also applicable to other hazards in emergency situations of many different kinds.

Background to This Report

In the 1949 program of *Suggested State Legislation*, the Council, cooperating with the office of Civil Defense Planning in the National Military Establishment, developed a Model State Civil Defense Act providing organizational arrangements to deal with natural disasters as well as civil defense.¹ Additional proposals were prepared for consideration of state legislative sessions in 1953 incorporating a model compact for interstate cooperation in emergencies and recommending appropriation of emergency funds for a governor's use until regular appropriations could be provided.²

In 1972 the Council, recognizing that legislative provisions thought useful in a civil defense context were not always well suited to meet other disaster problems and that vulnerability to disasters was steadily increasing, developed an Example State Disaster Act as an aid to state officials in strengthening their disaster legislation.³ Two years later the Council published revisions to that act to take account of the new federal Disaster Relief Act of 1974.⁴ At the request of the Federal Disaster Assistance Administration the Council, from 1972 to 1976, assisted legislators and legislative committees in a number of states to adapt these acts for use in their states.

In 1976 the Council published a report on comprehensive emergency preparedness planning in state government. That report, dealing with more than just natural hazards, presented suggestions for increasing the effectiveness of planning aimed at improving a state's capacity to handle emergency situations.⁵ The wide range of emergencies cited in that publication included those related to: "international conflict, threat of nuclear attack, significant natural disasters, endangering of the environment, economic distress, and resource or service shortages." That Council report recognized, as does this one, that many of the same policy and administrative issues and many of the same approaches and mitigating measures have applicability to hazards of widely different origin.

Along with the 1976 report and related to it, Council staff presented an unpublished memorandum to officials of the Federal Preparedness Agency and the Office of Management and Budget. The memorandum stressed a need for federal recognition that:

comprehensive state emergency preparedness planning encompasses: 1) readiness to deal with a full range of potential emergencies, including natural disasters, other peacetime emergencies, crises occasioned by shortages of resources or services, and emergencies that could arise in event of war or

enemy attack on the United States; and 2) plans for prevention of emergencies and disasters to the maximum extent possible, for reduction or mitigation of hazards, and for long-range recovery from emergencies and disasters as well as for responding to emergencies when they occur.

In 1975, the National Academy of Sciences published a report of the National Research Council's Panel on Public Policy Implications of Earthquake Prediction.⁶ That report dealt with the consequences of predicting events which can be the most sudden and severe of the natural hazards that threaten many U.S. residents, and should concern most public officials. It was that report which led the Council of State Governments to seek financial support from the National Science Foundation to examine policy, legal, legislative, program, and administrative issues related to the evolving technology of earthquake prediction.

After receiving that support, the initial effort in the Council's project concentrated on developing and conducting a National Conference on Earthquakes and Related Hazards, designed to promote interchange of information about those hazards among physical and social scientists and public officials from federal, state, and local levels of government. The conference, held in Boulder, Colorado, on November 16-18, 1977, was sponsored by the Council with the cooperation of the Natural Hazards Research and Applications Information Center of the University of Colorado's Institute of Behavioral Science. It brought together 100 persons for informal presentations and discussions which concentrated on the current status and future of earthquake prediction technology, evaluation of earthquake predictions, issuance of warnings and anticipated reactions to predictions and warnings, and measures for hazard reduction. Inclusion of earthquake-related hazards brought into the group's purview fires, floods, ground failures, and earthquake-induced sea waves (tsunamis).

Two significant observations, among others, were made at the conference. First, a comprehensive approach in disaster management can lend vital support for mitigating hazards from earthquakes as well as other natural hazards. Second, a case has not yet been made that it is cost beneficial in most states to spend much time and money on hazard response mechanisms designed solely for earthquakes; however, if these preparedness measures can help a community deal with other problems as well, then a much stronger case can be made for them. The Council's report on the conference was published in late 1978.⁷

Concurrently with planning the Boulder conference, the Council was organizing and arranging meetings of three committees of state officials, developed from and with the help of the National Association of Attorneys General, the Council of State Planning Agencies, and the National Association of State Directors for Disaster Preparedness. These three committees and their associations have reflected special concerns in some states about earthquakes, but they have also disclosed a general and anticipated reaction that most states and communities are more interested in and have greater concern for natural hazards which occur more frequently within their boundaries. The deliberations of these committees have contributed to findings and recommendations in this publication. Reports of these committees are included in the appendices.

Beginning in 1977, the National Governors' Association, in its research, publications, and official actions, has encouraged a comprehensive approach to emergency management. Included in this approach are natural hazards, civil defense, man-made hazards, and other kinds of emergencies. Considered essential to a comprehensive approach are mitigation and recovery as well as the ability to respond to emergencies when they happen.⁸

EXECUTIVE SUMMARY

The initial objective of this report is twofold:

(1) To identify basic elements deemed significant to the provision of effective programs dealing with natural hazards.

(2) To acquaint state officials and others with certain new federal emergency management policies, as reflected in or related to (a) the reorganization of federal emergency management functions and agencies through the creation in 1979 of the new Federal Emergency Management Agency and (b) the federal government's development of a program to implement the Earthquake Hazards Reduction Act of 1977.

1. A Base for Effective Natural Hazards Programs

Five elements believed basic to the development and conduct of successful natural hazards programs are identified. Summarized below, they call for changed thinking about these programs by many public officials at each level of government.

A Shared Responsibility

First is the recognition that the responsibility for public programs concerned with natural hazards is one that is shared by all three levels of government—federal, state, and local. This is a factor not adequately recognized or taken into account by past policies and which creates an extremely complex set of intergovernmental relationships that cannot be oversimplified and must be dealt with in reaching decisions on responsibilities, funding, and conduct of public services to contend with these emergencies.

Need for Comprehensive Programs

Public natural hazards programs should be comprehensive in nature, encompassing (a) a response to disasters when they happen, (b) pre-disaster mitigation of hazards to enhance safety and reduce losses, and (c) recovery measures that will also reduce damage and destruction should similar disasters occur again at the same locations.

National Leadership

National leadership in shared programs for natural hazards should be provided by the federal government. With 50 states and thousands of local jurisdictions involved, there is an important central role. The federal government

already has assumed this role in many research, weather, geologic, civil defense, and other services. Ways in which the federal government can contribute to the effectiveness of state and local programs are subjects for exploration by the new Federal Emergency Management Agency.

Effective Use of Executive Powers

The pervasive nature of organizational arrangements for emergency response, mitigation, and recovery programs at all three levels of government and the large number of agencies involved at each level make it essential that whatever organizational pattern adopted by the federal government, by each state, and in local jurisdictions makes maximum use of the directional, coordinating, and other management powers vested in their chief executives. Lesser officials may assist, even at times act for, the president, a governor, or a local chief executive, but they cannot be viewed as having inherent management authority to direct actions by agency heads who are responsible to the chief executive.

Continuing and Adequately Financed Planning

Planning for the mitigation, response, and recovery elements of a comprehensive natural disaster emergency management program must be viewed as a continuing function of management and must be adequately funded. It, too, must make use of the directional and coordinating powers of the chief executive, because many agencies are involved. Planning in the past too often has been looked upon as a job of preparing "plans" for envisioned, potential future emergencies—plans which too often have been found to be inadequate or inapplicable if an emergency occurred.

2. Assessment of Natural Hazards and Determining Measures for Hazard Reduction

In discharging natural hazards functions shared by the three levels of government, states have a special responsibility to provide leadership in addressing hazard threats facing their residents and, in doing so, to serve as a catalyst for services provided by federal, state, and local agencies.

Tasks best assumed by states include:

- Identifying and assessing hazards which are a potential threat to their residents and determining the applicability and possible usefulness of various hazard reduction measures.
- Assuring that local jurisdictions have authority which they may need.
- Performing services best provided by state agencies (and in many states these may well be the most critical services for establishing standards, mitigating dangers, responding to many disaster events, and making plans for recovery from the most serious disasters).
- Seeking information, advice, and help from federal sources when needed.
- Assuring cooperation with federal emergency programs and with other states in instances where objectives reach beyond those affecting individual states.

A state's analysts and planners can identify hazards of concern in a given state, based on historical experience as to incidence as well as on known geological and other factors. Such hazards should be assessed according to hazard characteristics such as probability, magnitude, intensity, frequency of duration, areas affected, speed of impact, number of locations, and patterns of occurrence. Of special concern are the risk to critical public facilities and locations and the potential social and economic impact of disaster events.

Measures to be utilized for reducing the impact of natural hazards by states and their local communities include such well-known ones as land use planning and management; use of effective building technology and regulation; lifelines engineering (applicable particularly to utilities, transportation, and communications systems); safeguarding critical facilities such as schools, hospitals, correctional institutions, and others essential in disaster response efforts; and maintaining a general readiness for response to potential hazards and disasters, including issuance of warnings and promotion of public understanding and knowledge. Other hazard reduction and protective measures can be based on available insurance coverage, plans for long-range post-disaster recovery, and use of a state's police power in dealing with protection of workers in hazardous locations, environmental safeguards, promotion of conservation, and measures for consumer protection.

The Special Section of this report summarizes general information relative to 14 natural hazards most common in the United States, highlighting the characteristics and incidence of each hazard and identifying possible hazard reduction measures for each, along with a listing of sources of information and recognized reference materials.

The feasibility of hazard reduction measures is an important determinant in developing programs for hazard mitigation, as are appraisal of their effectiveness in specific situations, reliability, social acceptability, environmental impact and cost impact. Many elements of such appraisals move into the realm of decisionmaking by appropriate political officials.

The report concludes its review of tasks to be undertaken by state government by pointing out that development of balanced hazard mitigation programs will be dependent on the use of systematic approaches for programming desired hazard reduction measures and for budgeting, locating, and allocating financial resources needed to implement those programs.

In addition to the general tasks of assessing hazards and determining hazard reduction measures described above, three specific problems related to these tasks are singled out for special attention by state government.

First are the recognized inadequacies of recording and reporting systems relative to disasters and the need for a better system, uniformly utilized, in order to provide information which can be helpful for hazard management planning and analytical purposes.

Second, a special characteristic applicable to earthquakes is noted. There is increasing expectation that scientific efforts will produce an ability to predict earthquakes, possibly even substantially in advance of earthquake events.

Creditable scientific evaluation of predicted earthquakes presents different kinds of difficulties and uncertainties, as well as opportunities for hazard reduction measures to mitigate damage. The former can include undesirable social and economic effects on individuals and communities, some of which can be allayed. The latter can lead to decisions or actions to protect people and facilities.

Third, attention is directed to a current federal program, authorized in 1972 by the National Dam Inspection Act, under which the U.S. Corps of Engineers is inspecting private dams and identifying those considered unsafe. Action to correct deficiencies in these dams will fall to their private owners and will possibly involve the states, inasmuch as corrective action and follow-up may necessitate use of the states' police powers. The Corps of Engineers has recently reported that only 20 states are believed to have a capability to administer their own dam safety programs.

3. Implementing a Comprehensive State Hazards Program

In order to perform the tasks identified above, most all states will need to face up to certain key implementation issues. Four are discussed in this report: state organization for a comprehensive natural hazards program; a state's relationships to hazard programs in local jurisdictions; issues affecting the potential liability of state and local officials in the issuance of warnings and taking (or not taking) other protective actions; and, finally, obtaining personnel resources needed to plan and develop hazard reduction policies and programs.

State Organization for Hazards Programs

Because most states have generally limited their organizational considerations to the response phase of disaster program management, they need to take a different approach toward organizing for a comprehensive natural hazards or emergency management job.

Three examples are cited. One deals with a state whose governor has legal authority for control of at least most state agencies and officials and a reasonably complete set of central staff agencies needed to help him manage the affairs of the state government. A second describes a state with a cabinet-type government, where the governor appoints secretaries for key state functions but, while he too has central management agencies to assist him, lacks full legal control over many state functions and agencies. A third example describes a state which has set up special agencies concerned with a single hazard, in this case earthquakes (in another state it could be hurricanes).

All three examples seek to provide an organizational framework for a comprehensive natural hazards approach, with facilities to coordinate state efforts in dealing with natural hazards and with a concern for mitigation, response, and recovery elements of the program. Recognition is given to maintaining effective interrelationships with federal and local governments, cooperative working arrangements among central gubernatorial management agencies, and continuing planning and policy/program development for comprehensive emergency management programs.

Authority and Assistance for Hazards Programs of Local Jurisdictions

State government responsibilities to local jurisdictions are emphasized because natural hazards do not respect jurisdictional boundaries; because few local jurisdictions are self-sufficient in meeting service needs of their residents, with state governments delivering or controlling many key services more or less directly out of state agencies; and because state government provides essential disaster program linkages with the federal government and with neighboring states.

Difficulties which local governments face in administering natural hazards programs are discussed, including recognition that a different perspective of hazards problems exists at local levels, that grass-roots political pressures handicap local officials in pursuing effective hazard mitigation measures, and that some local governments are too small or lack needed skills to deal comprehensively with hazards problems. A few exceptions are noted where encouraging leadership and action have been taken by local jurisdictions and officials.

The role of regional or substate planning agencies in the development of hazard mitigation tools and programs is noted, but it is evident that the potential of these agencies is far from being realized. This is a situation which can be improved with state leadership.

Legislative Authority and Legal Liability Issues

The need for states to assure the adequacy of their legislative authority to meet present-day challenges and achieve effective comprehensive emergency management for natural hazards is stressed, along with some of the problems that state legislators face.

Special attention is given to issues involved in any liability uncertainty in decisions to warn or not to issue a warning in the case of evaluated earthquake predictions. The Earthquake Hazards Reduction Act of 1977 assumes that earthquake warnings will be issued by the governor of a state. This is not the way in which warnings are issued for many other hazards, such as those coming from the National Weather Service. Despite a lack of consistency in methods for warning and instructing the public about impending dangers, considerations noted in this report have applicability in regard to various elements of hazard management programs, such as evacuation orders and other safety instructions and suggestions.

Of special significance is a conclusion of a committee created by the National Association of Attorneys General to work with the project of the Council of State Governments—namely, that state legislatures should enact legislation to expressly immunize both state and local officials from liability for good-faith warnings issued as a consequence of an evaluated earthquake prediction. A subsequent step to be considered is the possible development of suggested state legislation to deal with this and other legal issues described in the report.

Personnel Resources for Planning Hazard Reduction Programs

New federal concern for hazard mitigation and possible new hazard mitigation efforts in state, regional, and local agencies will find that there is a lack of planning personnel experienced and trained for analysis leading to hazard mitigation policies and programs.

Tenure (or merit system protection) is lacking for many such planning positions—to be filled by employees whose long-range vision is so important—even though state and local civil defense, disaster personnel partly financed by federal funds are assured such protection.

These are obstacles which can handicap the development of effective state and local programs.

Suggestions offered for consideration include projects to develop pertinent curriculum and graduate-level education programs for planning personnel and special training for planners and analysts now working in state, regional, and local agencies.

Footnotes

1. The Council of State Governments, *Suggested State Legislation Program for 1949* (Lexington, Ky.: 1948).
2. The Council of State Governments, *Suggested State Legislation Program for 1953* (Lexington, Ky.: 1952).
3. The Council of State Governments, *Suggested State Legislation, Special Report, Example State Disaster Act of 1972* (Lexington, Ky.: 1972).
4. The Council of State Governments, *Supplements to the Example State Disaster Act of 1972* (Lexington, Ky.: 1974).
5. The Council of State Governments, *Comprehensive Emergency Preparedness Planning in State Government* (Lexington, Ky.: 1976).
6. National Academy of Sciences, *Earthquake Prediction and Public Policy* (Washington, D.C.: 1975).
7. The Council of State Governments, *National Conference on Earthquakes and Related Hazards* (Lexington, Ky.: 1978).
8. National Governors' Association, *Comprehensive Emergency Management, A Governor's Guide* (Washington, D.C.: 1979). This publication lists other companion materials in the NGA State Emergency Management Series, produced by the Association's 1978 Emergency Preparedness Project.

2. A Base for Effective Natural Hazards Programs

While the principal emphasis of this report is on the assessment of natural hazards and their mitigation, many of the elements essential for administering these programs are applicable to emergency management in a broader sense. It is left to policymakers and practitioners in government to apply these characteristics to their situations, taking into account the breadth of their objectives and programs.

Five elements considered basic to the success of natural hazards programs are singled out in this chapter. While interrelationships and overlaps among them can be readily observed, each has basic relevance to the tasks and issues facing state governments that are discussed in Chapters 3 and 4.

A SHARED RESPONSIBILITY AT ALL LEVELS OF GOVERNMENT

Public responsibility for comprehensive disaster programs must be shared by all levels of government. This recognition becomes more apparent in the changed federal attitude toward emergency management.

There are very few natural disaster events which do not involve government in some way, and many persons affected receive government financial help or other public services. The more serious or damaging such events are or can be, the more likely they are to move beyond local authorities and on up to state and, subsequently, federal agencies. Almost any public response to disaster events by state or local agencies involves personnel partly funded by dual-purpose civil defense/disaster funds supplied by the federal government. If a presidential emergency declaration is made, federal disaster aid funds are provided from appropriations made by Congress to the president and, before the establishment of the Federal Emergency Management Agency, administered by the Federal Disaster Assistance Administration of the Department of Housing and Urban Development. Assistance from other federal agencies is also often provided.

Many factors support the concept that federal-state-local programs concerned with natural hazards, and also with many other emergencies, should be viewed as part of a continuing responsibility shared by the three levels of government.

One of these factors is that many emergencies are created by regional, national, or international policies or developments. Although these emergencies are sometimes related to natural hazards, they are more often related to civil defense, man-made hazards, and crises created by shortages of resources or services, or by a combination of these situations. It is unrealistic to expect that local and state governments can, without help, adequately plan for them or

finance needed actions even though they can and should participate in the implementation of desired policies and activities.

Furthermore, if state and local governments perform disaster mitigation, response, and recovery functions well, it is less likely that federal agencies need be called on for staff participation. The nature of these shared responsibilities is such that federal funds expended to assist state and local governments will contribute to community effectiveness and will have a desirable chain reaction in reducing federal involvement.

On the other hand, local officials point out that the more "invisible" a problem is at the community level, the less likely it is that local public attitudes will support use of community resources to deal with the problem and the more likely it is that the problem will escalate to state and federal levels. Potential disasters with unknown or uncertain probability are among such problems.

Another factor prompting recognition and acceptance of federal sharing of responsibility for disaster programs is the constitutional or statutory balanced-budget requirements applicable in state and local governments—requirements not likely to be relaxed.¹ These requirements, along with mounting population density in many hazardous areas and the increasing cost of disaster response measures, undoubtedly have been key factors contributing to the sizeable increase in federal funds spent for disaster aid.²

Federal recognition of the shared, intergovernmental nature of responsibilities for programs concerned with natural disasters and other kinds of emergencies is increasingly evident with the establishment of the Federal Emergency Management Agency. That agency is expected to be a central force in the implementation of comprehensive disaster programs at all levels of government.

The federal government's role in these shared responsibilities is also evident in the Earthquake Hazards Reduction Program transmitted by the president to Congress on June 22, 1978—a program which recognizes "the multiplicity of responsibilities for hazards reduction throughout our society."³ The program clearly states that it is based on a premise which emphasizes federal partnership, stating that "actions taken by the federal government alone will have little effect. State and local governments and the private sector have principal responsibility for [hazard reduction] action."⁴ This philosophy is certainly not applicable only to earthquake hazards.

Intergovernmental responsibility for disaster programs is further illustrated by the federal government's enhanced recognition of its role in disaster mitigation activities which are an essential element in comprehensive approaches to disaster program management.

A COMPREHENSIVE APPROACH TO HAZARDS PROGRAMS

A second element basic to successful natural hazards programs is that governmental disaster programs will be more fully effective if they take a comprehensive approach. This involves three stages: (1) plans and resources for responding to disasters when they happen, (2) plans and programs for mitigation

of hazards and reduction of risks in order to enhance safety and reduce losses, and (3) programs for recovery measures after disasters occur. Stage 3 consists of two phases: short-range and long-range recovery. The latter phase is designed to reduce damage and destruction should a similar event occur in the same locations.⁵

Federal support for a comprehensive approach is demonstrated by the president's statement to Congress transmitting Reorganization Plan Number 3 of 1978, which proposed the establishment of the Federal Emergency Management Agency: "Federal hazard mitigation activities should be closely linked with emergency preparedness and response functions."⁶

This presidential objective was given further emphasis by the Senate committee on Governmental Affairs in its report on the president's reorganization plan: "Mitigation . . . has begun to achieve some recognition as a more cost-effective approach to disaster management." The committee report also stated that "the reorganization initiative . . . [makes] clear the inherent linkage that exists between disaster mitigation and response." The committee urges that "the Federal Emergency Management Agency . . . begin the development of a rational, comprehensive national policy for [federal emergency management and assistance] functions and programs." The committee concluded one section of its report with a judgment that "these [proposed organizational] transfers will . . . materially contribute to the development of disaster mitigation as an important area of federal activity."⁷

The National Earthquake Hazards Reduction Program which the president sent to Congress recognized the importance of natural disaster mitigation actions as part of a well-balanced disaster program:

Each year the United States spends hundreds of millions of dollars in relief to victims of natural hazards and the reconstruction of damaged communities. Much, but certainly not all, of this post-disaster expense could be saved if mitigation actions were taken before the events occur. The nation must strive to find the proper balance—a balance that is both compassionate and cost-effective—between efforts to mitigate impacts of disaster and efforts to provide relief to victims.⁸

The significance of these statements may well represent a policy emphasis that, if implemented, will have a much greater impact than will the new federal organization for emergency management. Assistance to state and local governments for planning hazard mitigation programs has not been a significant concern of federal disaster aid programs. Emphasis, rather, has been on provision of post-disaster aid. Some federal civil defense and natural disaster planning funds have been used by state and local governments for hazard mitigation, most likely confined, however, to preparedness planning for improved response to disasters. In addition, other hazard mitigation efforts have been supported by federal categorical or project-type grants and programs and by federally financed construction. But these funds and programs have not been available on a basis that has encouraged or often even permitted a balanced approach to state and local hazard mitigation efforts.

Similarly, federal involvement in phase two of the third stage of comprehensive disaster management—long-range recovery of a disaster-stricken area—has also been less evident in the past, due in part to the lack of action to

implement Title V of the Federal Disaster Relief Act of 1974. However, the federal government has sometimes been involved with post-disaster recovery in different ways authorized by other statutes, particularly those concerned with economic development and small business assistance, but these actions have not always been judged helpful to desirable hazard mitigation objectives.⁹

Greater attention to this phase of stage 3 for comprehensive disaster management can likely be expected from the new Federal Emergency Management Agency. The Senate Committee on Governmental Affairs, in its report on Reorganization Plan Number 3, records one senator's emphasis that "it is absolutely imperative that this agency do more to solve the long-term economic problems that inevitably result from disasters." The director of the Office of Management and Budget responded that this was another area "in which further work needs to be done, and it is already within the purview of the new agency."¹⁰

NATIONAL LEADERSHIP IN HAZARDS PROGRAMS

Because 50 states and thousands of local governmental units are involved in disaster programs, with a great variety of interrelationships among them and their agencies and with the federal government, need for this third basic element of a successful natural hazards program is evident. National leadership to facilitate balanced and effective emergency management is essential, and the role of providing such national leadership necessarily rests with the federal government. It is from the federal perspective that the national dimensions of natural hazards can best be seen.

The administrative history of the federal government's many efforts to find a satisfactory answer as to how it should be organized for emergency management is replete with factors supporting concurrence with this third element. Most of these efforts in the twentieth century have sought to strengthen the role of the president and his executive office in dealing with civilian emergencies. They include assigning emergency management functions to the president, involving agencies in the executive office of the president and, as in the case of the new Federal Emergency Management Agency, assigning coordinating and planning functions by law or presidential delegation to the new agency director. These efforts are backed up by a committee constituted of key officials or agencies in the Executive Office of the President.¹¹ The Senate Committee on Governmental Affairs has stated that it views this committee as a significant and necessary element of the president's emergency management reorganization proposal.¹²

The president's leadership responsibilities related to disasters and other emergencies come about not just because he is the chief executive of the federal government but also in recognition of his position as the country's preeminent national leader, a position with special relevance in severe emergencies.

The president's Earthquake Hazards Reduction Program listed the provision of "national leadership" as the first step to be taken in "moving toward a national [earthquake hazards reduction] program." The program states that "a central focus is needed to stimulate and coordinate earthquake hazards reduction activities within the federal government and throughout the Nation." The new

Federal Emergency Management Agency is scheduled to assume that role, including "assisting state and local governments in planning and implementing their own programs."¹³ Federal officials are among those who recognize the importance of linking earthquake hazard reduction with mitigation efforts applicable to other hazards.

This leadership role will call for steps to assure that the federal government sets a good example by seeking to reduce existing or potential hazards in federal installations and facilities and by incorporating reasonable hazard mitigation policies in federal programs providing financial assistance to others. It should also give heed to applicable advice from a committee of outstanding citizens who a few years ago were recommending establishment of a Bicentennial Commission on American Government. The committee's advice was that "one of the primary emphases [of the proposed Bicentennial Commission] should relate to Federal responsibility to improve the capability of other governments in carrying out programs of shared concern."¹⁴

A noteworthy example of leadership provided by the federal government in one area of natural disaster management is the conduct and support of natural hazards research by a number of federal agencies and their financing of a clearinghouse for natural hazards research information. This clearinghouse serves as an indispensable resource to users of that information in state and local governments, a service which could not very well be provided by state and local jurisdictions. The Federal Emergency Management Agency should join with the National Science Foundation to assure continuance and further development of such support and should seek out other ways of contributing to effective hazards programs in this federal-state-local partnership arrangement.

ASSIGNMENT AND USE OF EXECUTIVE POWERS

Many agencies at each level of government are involved in preparedness for natural disasters and other kinds of emergencies. In proposing the new federal emergency organization, the president said that "wherever possible, emergency responsibilities should be extensions of the regular missions of federal agencies," and added that "many . . . specific . . . emergency-related authorities . . . have to do with department and agency responsibilities to plan for the performance of their regular missions under emergency conditions."¹⁵ Similar reasoning applies to state and local levels of government.

Because of the pervasive character of the organizational arrangements applicable to emergency management, it follows that the directional and coordination authority of the chief executive—vested in the president, governors, and local executives—is the essential authority needed in seeking and assuring effective direction and integration of agency efforts. These executives are also the leaders to whom the public rightly looks for guidance in emergency situations and are the ones to whom legislative bodies are most likely to assign emergency powers.

Lesser officials do not have inherent authority to coordinate and direct planning and actions by agencies whose heads are responsible to a chief

executive. They may be given specific authority by delegation, but it must be recognized that they discharge it only on behalf of or in the name of a chief executive. Many factors can inhibit their effectiveness if they obtain or exercise authority in any other way.

A comment on emergency management is appropriate at this point. In serious emergency situations—for example, following a severe disaster—across-the-board cooperation from agencies which have roles to play and which can be helpful in response efforts can usually be expected. This may not be the case in connection with policies or actions under non-emergency conditions—for example, in planning or implementing hazard mitigation measures. This situation underlines the importance, in a comprehensive approach to emergency management, that care be exercised in the way emergency powers are assigned and that authorized arrangements assure effective use of all appropriate agencies, in both emergency and nonemergency situations, under direction which fully utilizes the powers of the chief executive.

PLANNING NOT A SOMETIME THING

A fifth characteristic which this report singles out for special attention is the need that planning for each stage in disaster programs—mitigation, response, and recovery—be viewed as a continuing function of management, receiving continuous financial support and coordination. This special emphasis is given because too much preparedness planning in the past was temporarily stimulated by a recent emergency and has been directed to the preparation of plans that ended up “on the shelf,” often out of date by the time they were completed, without means for assuring current effectiveness and helpfulness to management.

Preparedness planning is a subject treated in greater detail in the Council of State Governments’ 1976 publication, *Comprehensive Emergency Preparedness Planning in State Government*. That report defined planning as “the organized and continuous interaction of elements in the management process: goal definition and problem analysis, policy development, program design, resource allocation, and program evaluation, with coordination at various stages imposed on participating units and levels of government.”¹⁶

In this context, planning is not a function of any single staff or operating agency; it is all of the above elements of management performed in many different places as part of a process that is relevant to current management decisionmaking. Planning, like the stages of emergency management, is also pervasive at each level of government, thus contributing to problems of coordination and, again, necessitating constructive use of the chief executive’s powers in the coordination of the planning process.

Planning will not be possible without financial resources to support it. A special symposium in the *Public Administration Review* of May-June 1977 points out that “Lack of resources for planning has beset the development of policy analysis in states and communities from the very beginning. Even after the federal government launched a major campaign for decentralized decision making, neither federal aid adequate for the task nor sufficient state and local

appropriations has been forthcoming." What is needed, the article points out, is "the design of a new structure of support that would encourage improvements in state and local governance and decision making."¹⁷

The Federal Emergency Management Agency, with support from the Office of Management and Budget, may find it necessary to supply this lack of resources by adopting a suggestion of the chairman of the National Governors' Association subcommittee on disaster aid: "If only a very small percent of the amount now budgeted by the federal government for post-disaster aid were made available for hazard assessment and mitigation planning, it would be possible to save lives, reduce social and economic losses and reduce federal disaster response expenditures."¹⁸

Footnotes

1. California's Proposition 13 and the national significance of that action cannot be overlooked when considering inhibitions applicable to state and local decisions on allocating financial resources to disaster programs. There is current interest in amending the U.S. Constitution to require a balanced federal budget. State and local budget balancing requirements are now law; a federal requirement is not and may not be. Even if adopted in one form or another, indications are that various options and special provisions are likely which would assure flexibility in meeting emergency situations, even under a balanced federal budget requirement.

2. The federal budget for fiscal 1980 shows outlays of \$241 million from the disaster aid funds appropriated to the president. These appropriations for fiscal 1970 and succeeding years have hovered around \$200 million each year except for a peak of \$440 million in fiscal 1978, occasioned by severe drought conditions in many parts of the United States. These figures are to be contrasted with appropriations in the late 1950s and early 1960s of \$25 million to \$50 million; the fiscal 1960 budget called for no new appropriations, only the expenditure of \$11.5 million from balances carried forward. The National Governors' Association, recognizing that disaster aid from the appropriation to the president is only part of the federal disaster aid provided to the states, estimates current annual federal aid for presidentially declared disasters at \$500 million.

3. Office of Science and Technology Policy, Executive Office of the President, *Fact Sheet on the National Earthquake Hazards Reduction Program* (Washington, D.C.: June 1978).

4. Executive Office of the President, *The National Earthquake Hazards Reduction Program* (Washington, D.C.: June 22, 1978), p. 3.

5. This report of the Council of State Governments subdivides comprehensive disaster management into three stages: mitigation, response, and recovery. The National Governors' Association and some others add a fourth stage, "preparedness," falling between mitigation and response, encompassing activities applicable to warning systems, stockpiling, resource inventory, and certain hazard plans primarily related to disaster response. Optionally, these activities can be viewed either as mitigation activities or as activities constituting a preliminary aspect of the response stage; this report puts them in the latter category. The "recovery" stage of disaster management can be divided into two parts, short-range and long-range; this report tends to look at most short-range recovery as part of responding to a disaster event, with long-range recovery viewed as quite a different kind of activity.

6. Message from the President of the United States Transmitting Reorganization Plan Number 3 of 1978, to Improve Federal Emergency Management and Assistance (Washington, D.C.: June 19, 1978).

7. U.S. Congress, Senate, *Report of the Senate Committee on Governmental Affairs on Reorganization Plan Number 3 of 1978*, Report N. 95-1141 (Washington, D.C.: August 23, 1978), pp. 13-14.

8. Executive Office of the President, *The National Earthquake Hazards Reduction Program*, p. 3.

9. U.S. Congress, Senate, *Report of the Senate Committee on Governmental Affairs*, p. 11 (reference to testimony by George M. Elsey, President of the American National Red Cross, citing

conflict between Small Business Administration disaster loan regulations and the intent of the federal flood insurance law).

10. Ibid. pp. 32-35.

11. The president's message transmitting the reorganization plan to Congress advised that the committee would be established by executive order to comprise the Federal Emergency Management Agency director as chairman; the assistants to the president for national security, domestic affairs and policy, and intergovernmental relations; and the director of the Office of Management and Budget.

12. U.S. Congress, Senate, *Report of the Senate Committee on Governmental Affairs*, p. 10.

13. Executive Office of the President, *The National Earthquake Hazards Reduction*, p. 8.

14. National Academy of Public Administration, *Bicentennial Commission on American Government* (August 26, 1975), pp. 10-11.

15. Message from the President of the United States Transmitting Reorganization Plan Number 3 of 1978.

16. The Council of State Governments, *Comprehensive Emergency Preparedness Planning in State Government* (Lexington, Ky.: 1976).

17. Selma J. Mushkin, "Policy Analysis in State and Community," *Public Administration Review* (May/June 1977), pp. 245-53.

18. Governor Mike O'Callaghan, letter to Philip H. Smith, Assistant for Natural Resources and Commercial Services, Office of Science and Technology Policy, Executive Office of the President (April 17, 1978).

3. Assessment and Reduction of Natural Hazards

Accepting the presumption that hazard mitigation is desirable—reducing the dangers and costs of natural hazards—what role can state government best play, in conjunction with federal and local agencies.

The federal government will continue to conduct important activities to that end, apparently with stronger mitigation emphasis and leadership derived from new plans and policies discussed in Chapter 2. Among these activities are the prediction of storms and other natural hazard events; research leading to helpful delineation of geologic, weather, and other hazards and to ways for mitigating their harmful effects; provision of information regarding the incidence and nature of potential disasters and risks; and provision of financial and technical assistance to state and local governments and to various elements in the private sector.

Local government can also take significant action to mitigate natural hazards through its land use, building regulation, and other activities, but its contribution is more limited if a jurisdiction is small or if the hazard is large and mitigation complex.

State government can perform a special mission in this shared responsibility for reducing natural hazards. Part of the mission is the provision of both leadership to local jurisdictions and state residents and liaison with federal agencies, part is the performance of specific services which are best conducted at the state level, and part is serving as a catalyst for services provided by federal, state, and local agencies. A state's tasks include leadership and services in (1) identifying the natural hazards most likely to constitute a threat to the state's communities and residents and assessing the risks which such hazards entail, and (2) determining, sometimes in general terms and sometimes on a site-specific basis, what hazard reduction measures can best prevent disasters or assure reasonable levels of safety.

These two tasks are basic ones calling for attention from state government officials and personnel, both directly and in concert with federal and local governments. These are the tasks with which this chapter is concerned.

IDENTIFYING AND ASSESSING A STATE'S NATURAL HAZARDS

No state or area within a state is free from potential disaster due to natural hazards. In order to develop a program for mitigation of those hazards which present the greatest danger, the obvious initial step is to identify the natural hazards which are likely to occur in the state. The second part of this task is assessing the risk which each hazard presents and the potential damage it can cause.

Identification of Natural Hazards

The natural hazards affecting a state can primarily be identified by historical occurrence, as well as by a wide range of factors which make them a potential source of danger.

This report considers 14 natural hazards as those most common in the United States. They are:

Avalanche	Storm surge
Coastal erosion	Tornado
Drought	Tsunami
Earthquake	Unstable soil
Flood	Volcano
Hurricane	Windstorm
Landslide	Winter storm

The Special Section of this report describes these 14 hazards. In that section each of the hazards listed above is discussed and a number of maps of the United States are included, with an indication of the incidence of the hazards in each of the states.

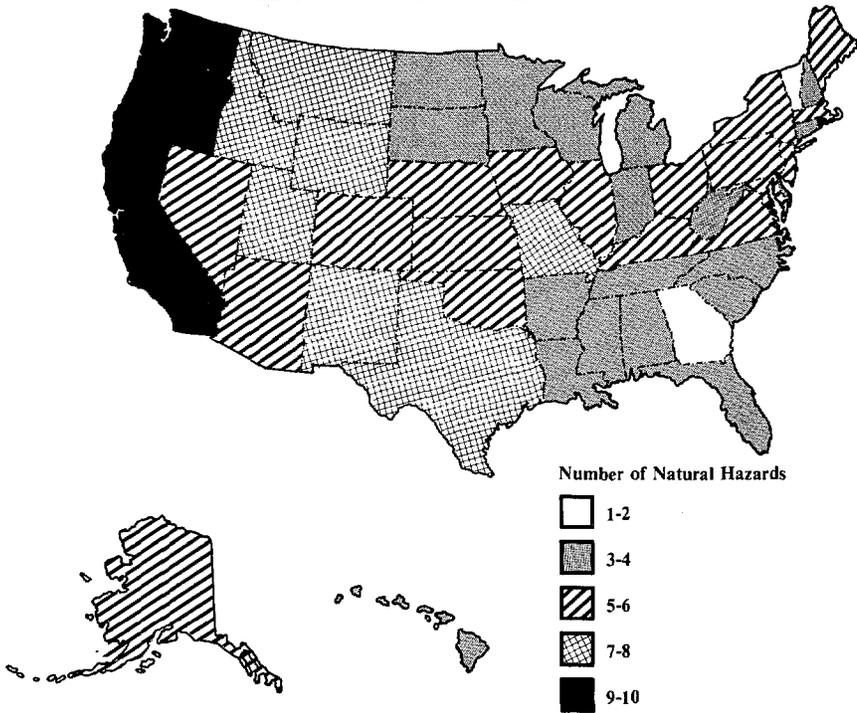
Figure 1 illustrates that all states have high potential for some of these 14 hazards. States such as California, Oregon, and Washington may experience disasters resulting from nine or more of the hazards. By contrast, Georgia and Vermont will probably be affected to an appreciable degree by only one or two of the hazards. The number of hazards shown for each state on the map is derived from hazard maps presented in the Special Section. A hazard is counted in a state only where there is reasonably high potential for disaster from that hazard, as indicated by the information in the Special Section.

Natural hazards can also be categorized by their potential for economic impact. One method is by an analysis of possible building losses, which the J. H. Wiggins Company of Redondo Beach, California, did for nine hazards in 50 states. Figure 2, developed in that analysis, shows average annual loss from the nine hazards as a percentage of a state's total building value for 1970 conditions. These figures are derived from historic data and by projections over a 30-year period from 1970 to 2000. Florida and Louisiana stand to suffer the greatest percentage of such loss. The analysis concluded that "unless significant new steps are taken, the cost of replacing or repairing buildings destroyed and damaged by the nine natural hazards studied, during a typical year, are likely to increase more than 85 percent in the 30-year period between 1970 and 2000."¹

Of the 14 natural hazards listed above, several such as floods, windstorms, and drought are common in varying degrees in all states. Another hazard common to all states but virtually hidden and not well understood is unstable soils. Annual damage to buildings from this hazard ranks second only to that from floods and is tied with that caused by hurricanes and storm surges.

Many of the hazards are found only in certain states, sometimes limited to specific areas within states; this is true of avalanches, tsunamis, and volcanoes in western and Pacific Coast states and hurricanes and storm surges in Atlantic and Gulf Coast states. Four hazards—earthquakes, volcanoes, coastal erosion, and

Figure 1
DISASTER POTENTIAL OF STATES
FROM NATURAL HAZARDS*



*Sources: This figure is based on the number of different kinds of natural disasters experienced in each state. The information used for arriving at the number of natural hazards came from Maps I through 14 in the Special Section of this report. The specific criteria from the maps, by natural hazards, was:

Avalanche—all indicated areas.

Coastal erosion—shorelines with $\geq 10\%$ critical erosion.

Drought—arid and semiarid areas.

Earthquake—areas subject to potential major damage.

Floods—181 or more floods and flash floods from 1945-76.

Hurricane and storm surge—counted as one hazard for east and Gulf Coast states.

Landslide—all indicated areas.

Tornado—areas frequently experiencing tornadoes.

Tsunami—all west coast states, Alaska, and Hawaii.

Expansive soil—regionally abundant areas.

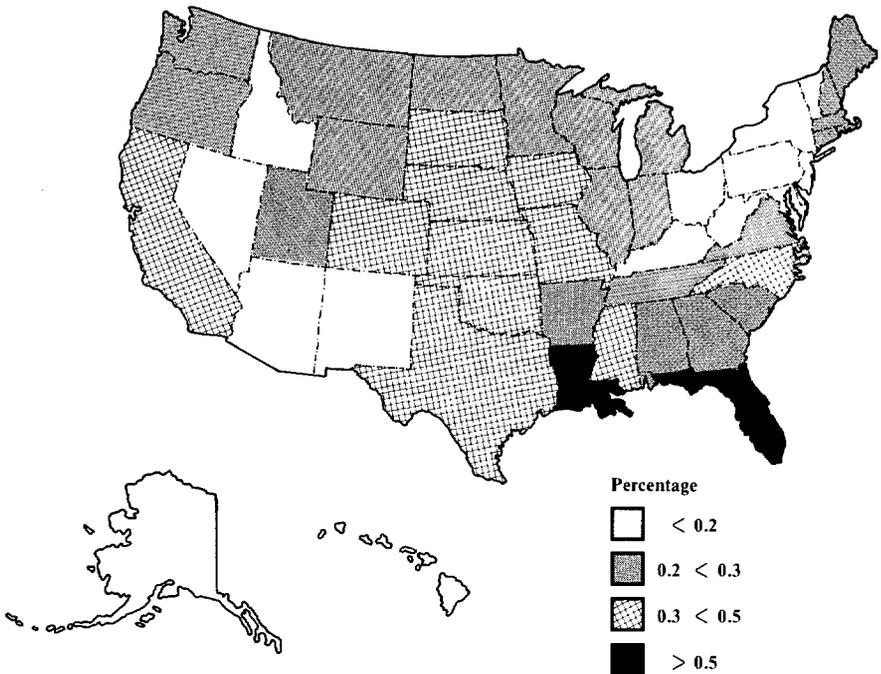
Volcano—all indicated areas.

Windstorm—all indicated areas.

Winter storm—areas of ≥ 10 mean annual days with snowfall > 1 inch and ≥ 90 days below freezing.

landslides—are commonly considered to be a threat in geologically unique areas but, except for volcanoes, they actually have a high potential for disaster in more than 20 states. Tornadoes carry the highest probability in the central plains states but have occurred in most of the states. The winter hazards of snow and ice

Figure 2
ANNUAL LOSS AS A PERCENTAGE OF TOTAL STRUCTURE
VALUE FOR NINE NATURAL HAZARDS*



*Source: J. H. Wiggins Co., *Building Losses from Natural Hazards: Yesterday, Today and Tomorrow* (Redondo Beach, Calif.: forthcoming in 1979). The nine hazards are: earthquake, landslide, expansive soil, hurricane wind/storm surge, tornado, riverine flood, local wind, local flood, and tsunami.

storms cause an increasing number of disasters in many states because of the fragile nature and the growing number of technologically dependent, densely populated areas.

Often a natural hazard not only presents a problem in itself, but it also can unleash or create additional hazards. Earthquakes are a major example of this type of chain reaction because they may cause tsunamis, landslides, coastal erosion, flooding, and fires. Floods precipitate landslides and increase coastal erosion. Some hazards come in what can be described as a "family." Tornadoes are almost always part of a storm system which includes wind, rain, hail, and lightning. Hurricanes may spawn such storm systems. Additionally, and to an increasing degree, many natural hazard events can trigger disasters from man-made hazards through events such as dam failures from earthquakes, power outages from ice storms, and release of toxic chemicals by earthquakes and floods. Finally, the interrelated impact where different hazards occur at the same time, as in the case of winter storms and energy shortages, has been amply demonstrated in recent years.

A common feature of many disaster events caused by natural hazards is that danger is created only by the presence of man and his settlements. Man's tendency to establish communities near water has led many floods and much coastal erosion to cause disasters due to the high damages inflicted upon such communities. Recent settlement patterns resulting in higher population density in formerly remote areas also have made many hazards an increasing threat. Well-known examples include resort and permanent homes built to take advantage of picturesque views along the San Andreas fault and the colorful environment of Hilton Head Island; construction safeguards and adequate means of evacuation may not accompany the habitation of such settlements.

The identification and assessment of natural hazards which present risks is an undertaking handled by planners, who are used to accumulating data. Planners from various state, substate, and local agencies can participate in and contribute to this task; and state and local disaster response personnel have special, applied experience which is useful in such undertakings. Federal agencies, many of which are identified in the Special Section of this report, are primary sources of needed data, as are universities, research and consulting organizations, particularly those which have been the recipients of grants from agencies such as the National Science Foundation, and entities which will comprise the Federal Emergency Management Agency.

Recent research, however, has shown that one of the gaps in disaster program management throughout the United States is the lack of good records on actual disasters. With assistance from the federal government, states are encouraged, in concert with one another, to take steps to develop effective disaster data recording and reporting systems and to require reporting and assemblage of such information which can be helpful for planning and analytical purposes.²

Assessment of Natural Hazards

In developing a program aimed at reducing disasters and losses from natural hazards, an assessment of those hazards likely to be experienced is an important step in order to determine which carry the most risk. Accordingly, it is a step to be given high priority in mitigation efforts.

Planners and program developers will find it desirable to assess natural hazards from at least these three points of view: (1) hazard characteristics, (2) impact on critical facilities, and (3) social and economic impacts. Other analytical factors are described in *The Environment as Hazard*, by Ian Burton, Robert W. Kates, and Gilbert F. White.³ Each of these factors must, of course, be related to the specific areas or location chosen for analysis, although these very factors may determine the location selected for analysis.

State, substate, and local government analysts will find many hazard maps developed by federal agencies useful in delineating hazards and planning hazard reduction measures, but such maps are not likely to be on a large enough scale for site-specific needs. A fertile field for state and local planners is the development of locally useful maps. A great deal of that work has been done by many state and

local agencies. Again, this is a kind of activity in which state, substate, and local planners have had pertinent experience. Often maps which they have developed for other purposes will have utility in hazard mitigation programs.

Hazard Characteristics

Probability. This characteristic identifies the probability of an area experiencing a particular kind of natural hazard. Probability is, of course, a factor related to the historic experience and any geographic, geological, meteorological, or other data useful in determining that the hazard is one likely to occur; thus, information contributing to the development of the map in Figure 1 and those in the Special Section has special pertinence in this analysis.

A more refined delineation is necessary as the size of the area being considered decreases and as the importance of probability determination increases in the hazard assessment or hazard reduction planning process. The delineation is always subject to differences resulting from the quality and currency of the data and the methods used; the analysis accordingly must allow for appropriate revision, especially as new data becomes available. A number of such analyses have been done and examples of data assembled for them are available to those undertaking these more refined delineations. The mapping of floodplains illustrates a delineation process that identifies flood hazard probability to a reasonably reliable degree. The analysis of "tornado alleys" based on historical occurrence records is another example, though far less refined. Admittedly, as previously indicated, better reports and records on actual disaster events are needed, and improved systems can enhance the value of probability and other assessments.

Magnitude. Magnitude has been defined as a natural hazard characteristic which identifies a measure of size exceeding a common level. In the case of a flood, it would be the maximum height reached by the flood waters or the maximum discharge at a given point. Describing the magnitude of an event often calls for the imaginative use of data obtained for other purposes or, in some cases, the generation of a new type of data. Some hazards such as floods and earthquakes have well-established measures of magnitude such as the height of flood waters or the Richter scale for earthquakes. As to the latter, an upper limit has not been defined, and the lower end reaches into a minus scale; a large earthquake would register 6 and a great earthquake, 10 times more powerful, at 7 or more, with the largest earthquake on record registering about 8.9. The magnitude of other hazards such as tornadoes or lightning are much more difficult to measure.

Intensity. This characteristic differs from magnitude in the same way that a light bulb has a certain magnitude when measured in watts and a certain intensity when measured in lumens. Hazards often can be measured for both characteristics. Earthquakes can be measured, for example, as to magnitude on the Richter scale, which gives a measure of the energy released, and as to intensity on the Modified Mercalli scale, which measures the observed effects of the earthquake. The intensity measure is purely subjective, e.g., window shaking,

cracks in the ground, and other occurrences determined by observation. Such effects, in many cases, are determined by the location, design, construction, and age of a structure. It ranges in scale from I to XII (the latter being classed as "complete destruction"). Floods can be measured for magnitude (water level) and intensity (force of flow).

Other Characteristics. There are a number of other characteristics of natural hazards that can be used in assessment, six of which are noted here. *Frequency* indicates how often an event of a given magnitude may be expected to occur. *Duration* refers to the length of time a hazard event may persist. *Area covered* indicates whether a hazard is limited, like the path of a tornado, or broad, as with most droughts. *Speed* refers to the time between a hazard event's first appearance and its peak. *Number of potential locations* indicates areas susceptible to a hazard such as floods which occur in many locations and volcanoes which occur in very few locations. Finally, *pattern of occurrence* refers to time frames when hazards can be expected, such as volcanic eruptions with a random time distribution and hurricanes a seasonal one.

Impact on Critical Facilities

Another basic assessment should analyze the possible risk that hazard events may have for certain facilities particularly critical to public needs or which affect large groups of people. This would include structures and facilities such as schools and churches; others used for response and disaster assistance such as police, fire, and medical facilities; those that affect energy such as generating facilities and pipeline pumping stations; and those that if severely damaged can trigger still different disasters such as dams and nuclear-powered generating facilities.

Increased environmental concern has in recent years caused such facilities to be located with greater care in order to reduce their disaster potential. However, vast capital investment has been made during past years in facilities that were not planned or constructed with disaster potential in mind. These existing sites and facilities should be identified and considered in a comprehensive hazard reduction program. Many of these facilities are owned and operated by public bodies. State and local governments have a special responsibility as well as a special liability in such instances.

Another critical facility is land and its uses. Of particular concern here are uses of land which would be recovered slowly or not at all following a disastrous event. Because of the relative durability of land, disaster events such as earthquakes or extreme, accelerated coastal erosion are of great concern. Of special concern, too, are lands devoted to agriculture, to human habitation, to energy-related production, and to recreation. Therefore, comprehensive emergency management must look to the best uses for land in relationship to the natural hazards that the land could experience.

Bridges on evacuation routes and facilities that will be needed in disaster response efforts acquire special significance in the assessment of hazard impact.

How much attention is given to this phase of the hazard assessment process demonstrates the interlocking relationships and responsibilities among local, state, and federal agencies. Many factors are beyond the scope of local government responsibilities, and the concern of federal agencies may be remote. Therefore, state government leadership may likely be the key ingredient, the catalytic agent, especially in initiating actions aimed at hazard mitigation. Further attention will be given to many of these critical facilities, beginning on page 26.

Social and Economic Impacts

The social and economic impacts of natural disasters will, obviously, be larger and of greater concern where population density is high, where buildings are concentrated, and where the economic well-being of residents and commercial organizations can be adversely affected. However, smaller communities with weaker financial bases and few key facilities may suffer greater relative social and economic impacts than larger urban areas if extensive damage occurs and their few key facilities are destroyed.

Demographic information and socioeconomic data are important tools for the analysts engaged in making such assessments of natural hazards. Behavioral characteristics and reactions are also significant. For instance, one must consider those populations that are made immobile for physical or social reasons. This would include inmates of prisons and other detention facilities, residents of hospitals and nursing homes, and students in educational institutions. Populations dependent on public transit or limited-volume traffic arteries also require special consideration. Locations where warnings will not give adequate time for evacuation because the roads or bridges would restrict travel flow must be acknowledged; Atlantic and Gulf coast areas face this possibility during hurricane season. If earthquake prediction becomes a reliable science for short-range predictions, could San Francisco be successfully evacuated in time? People are very mobile, more so than most of their creations, but still they require space and time to evacuate and relocate. Of course, in a comprehensive hazard reduction program, hazard reduction would emphasize placing population concentrations in areas of low risk.

The urbanization trends that accompany industrialization have resulted in vast concentrations of buildings in relatively small areas. These areas become a major concern in hazard reduction for a variety of reasons. Where such concentrations have resulted in high population densities for residential, commercial, or industrial purposes, the potential impact of disasters from natural hazards should be determined. Of equal concern are those building concentrations that have major economic or social importance. In some cases, both density and importance may be factors for consideration, as in the destroying or incapacitating of a major regional financial center.

SELECTING AND APPRAISING HAZARD REDUCTION MEASURES

When a state is aware of the natural hazards with which it will likely have to contend and has assessed those hazards in terms of the risks which they present

and the impact they could have on the state's residents, it is better prepared to determine which hazard reduction measures should be taken to lessen the harmful impact of such hazards. This determination depends not just on selecting measures which can be effective, but also encompasses the promotion of safety by setting standards or requirements applicable to hazard reduction measures administered by local jurisdictions as well as state agencies. It also depends on appraising how feasible hazard reduction measures will be; the latter appraisal involves such issues as social acceptability and reliability. Finally comes the implementing job of programming, prioritizing, budgeting, and accomplishing desired reduction measures. The pay-off from a comprehensive natural hazards program comes only through the development and implementation of a program of effective hazard mitigation measures designed for the kind of hazards which the state and its people should be prepared to face. The cost of such measures may well be more than offset by reduction in losses of life and property which would otherwise be sustained and by lessening the amount of public funds which would be spent for post-disaster aid.

Measures for Reduction of Impact from Natural Hazards

Many hazard reduction measures—particularly those related to local land use planning and regulation and to locally administered building codes, public utilities, and protective services—are primarily dependent upon authority vested in local jurisdictions by state constitutions and statutes. Because it is the state that actually grants that authority, the state has the power to lay down conditions under which that authority is to be exercised and to determine goals and objectives which best serve the interests of the greatest number of state residents. State government, indeed, should be concerned with evaluating local actions to determine if those interests are well served. This can encompass oversight by the legislature as well as administrative evaluations by state agencies.

However, state government will also encounter situations when, sometimes even on a site-specific basis, it may best identify problems for attention either by its own agencies or by local jurisdictions.

Land Use Planning and Regulation

One mitigation measure with hazard reduction potential is land use planning, followed by effective regulation or management of land use. Yet this approach to a diverse and complex problem has hardly begun to be effectively applied. Management of land in the United States represents a historic and continuing battle directly bound up in private and public rights. Economic forces seek the highest return on use of the land. Tax systems and short-term investment policies tend to minimize land use planning as an effective means of long-term land management serving disaster mitigation purposes. In addition, state government tends to be reluctant to manage land use either through zoning and subdivision controls or through capital improvement planning. Worse yet, many governments have not instituted effective disaster mitigation practices in the management of public lands which they own.

Most state governments have passed on responsibility for traditional zoning controls over land use management to local governments. Few guidelines have been provided by the states. For instance, only 12 states set forth specific guidance on the content of a local comprehensive plan. California requires disaster mitigation-related elements in such a plan. However, land use management is too important as a hazard reduction measure to be ignored. Activities which can be undertaken include delineation of hazard zones (e.g., location of geologic hazards), development of hazard-reducing land use policies consistent with safety or economic objectives determined by the state to be in the public's best interests, modifying tax structures in order to provide an incentive for desirable mitigation-related land use decisions, encouragement of public finance policies that discourage new development and growth in hazardous areas, and development of housing policy and regulations that will reduce hazard vulnerability.

Natural hazard mitigation through land use policies should in some instances be sought as a primary end-purpose of such actions, particularly, for example, in the case of certain floodplains or fault zones where public safety is the prime objective. In other instances, hazard mitigation may be a secondary purpose when land use measures are initiated for other reasons.

A number of states are increasingly concerned with land use problems. Some states, recognizing the effects of "urban sprawl," inappropriate use of marginal lands, efforts to increase public revenue bases via new developments which create density exceeding the capacity of essential public services, land uses which create undesirable environmental pollution, and other factors generating a possible need for state land management action, have sought to regulate the development of land by a variety of means. As stated in a Council of State Governments' publication in 1974, "It is clear that the authority rests with the states to legislate for the promotion of health, safety, and welfare of their citizens, . . . there is no constitutional necessity for the delegation of all of the [police] power to the local governments."⁴

The Council's 1974 report also points out that in recent years there has been a greater number of measures asserting the rights of states to regulate developments by exercise of their inherent sovereign police powers. The report identifies states which are taking steps to regulate land utilization where critical areas or uses are involved (e.g., coastal wetlands, shore land protections, location of oil terminals and nuclear facilities, preservation of agricultural lands, and developments affecting air and water quality). In 1974 the National Governors' Association adopted a position supporting a need in the 1970s to face issues of national and statewide land use planning and decisionmaking in a way that seeks, among other objectives, quality environment, wise and balanced use of the nation's land and water resources, and protection of scenic environmental and cultural amenities.

Building Technology

Construction codes are a traditional approach requiring use of building technology to assure both safety and value. Man-made structures are involved in

most of the losses caused by natural hazards. Advances in quality and understanding of modern building materials and the behavior of structures have contributed to the ability to construct disaster-resistant buildings. A 1972 report of the Office of Emergency Preparedness stated that the greatest mitigation of hazards will come through safe construction.

Building regulation authority rests basically on state government, but with most responsibility for adoption and enforcement of building codes passed on to local government. Over 5,000 local codes have been adopted in the United States, based largely on four model codes developed by code organizations, each of which tends to be oriented to and predominant in certain sections of the country. Twenty-two states now have statewide building codes, most of which are mandatory. Building codes generally include minimum safeguards for fire safety and prevention of collapse, health standards, and electrical and sanitary as well as structural aspects of construction.

The federal government has a significant impact on construction through requirements specified for federally assisted construction; through construction of its own buildings, dams, etc.; and through research and development of performance criteria for improved building practices by the National Bureau of Standards.

Hazard reduction is approached primarily through code requirements applicable to new construction, with older structures subject to code requirements only when major improvements are undertaken. It is not economically feasible to apply new and safer standards to the large number of existing structures which admittedly could benefit from those standards. Some jurisdictions, however, have undertaken sensible approaches to problems of older buildings by determining those presenting the greatest hazards and seeking mitigation largely through voluntary compliance on a priority basis. Others have sought to eliminate unduly dangerous features of old buildings, such as parapets and cornices deemed unsafe in areas subject to seismic activity.

Professional organizations have influence. The American Institute of Architects, the National Association of Home Builders Research Foundation, and the American Society of Civil Engineers have given attention to improving seismic safety in construction. The new National Institute of Building Sciences, in the spring of 1979, held a conference on construction to enhance seismic safety. The development and impact of this new institute may well contribute to strengthening building standards and to greater uniformity in model building codes.

Standard state codes bring with them both advantages and disadvantages. On balance, standard codes, with mandatory application of minimum requirements to local jurisdictions, appear to have merit, provided, (1) sufficient flexibility is permitted so that added local requirements can be applied when local conditions indicate their necessity, and (2) the codes are regularly modernized to take advantage of new developments affecting safety and economy. In instances where safety and economy have to be weighed against one another, not only should careful professional analysis be given by such organizations as the

National Institute of Building Sciences and the National Bureau of Standards, as well as by public policy officials, but again, flexibility should be assured so that localities can establish higher standards than those prescribed by state codes.

The possibility of natural hazards damage has not always motivated the strengthening of code provisions, and it is not surprising to find that suggested model codes and codes adopted by state and local jurisdictions often fail to include provisions specially designed to mitigate natural hazards. Technology assuring greater seismic safety of structures in earthquake areas, protection against wind damage, floodproofing, and the like is advancing. However, the higher concentration of buildings and people in areas at risk emphasizes the importance of these objectives. Here is a matter in which the new Federal Emergency Management Agency may take an interest and stimulate incentives to hazard mitigation.

Despite the need for building codes, state and local officials recognize that codes based on those developed by model code organizations are not likely to encompass steps to alleviate damage that many architects, engineers, environmentalists, and others concerned with natural hazards and resources would consider desirable in order to provide maximum individual as well as public protection. Because the model codes necessarily consider a wide range of issues and are the product of membership organizations, it is to be expected that they will reflect compromises designed to meet divergent views.

The model codes will have their greatest impact in instances where public health and safety are involved. They are less likely to affect the impact of hazards on private property, where public risk is deemed not to be involved. In fact, the extension of enabling authority to local governments may be restrictive in its application to such property. Questions of public vs. private interests and the incidence of damages and costs are valid issues of policy and legislative concern. (The importance of costs in legislative considerations is referred to in Chapter 4, page 49, and in Appendix D.)

Finally, it should be noted that building safety restrictions placed by government jurisdictions on their own projects or by federal, state, or private financing authorities may have greater impact on design and construction standards than do those in building codes. Both legal and financial liability are key factors in such instances. This does not imply, however, that similar additional safeguards are not proper subjects for consideration in legislative enactments having broader applicability.

The special responsibility of the states is to keep abreast of advancing technology for the same reasons that the new technology is getting increased attention from professional organizations and disciplines. The objective is to strengthen the effectiveness of codes in dealing with hazards, and to assure effective inspections meeting state as well as local needs and requirements. The National Conference of States on Building Codes and Standards, an organization of state building officials, can assist states in assessing these objectives through its active participation in programs concerned with many kinds of natural hazards. It also serves as a medium for calling states' attention to technical and administrative developments related to code administration.

Lifelines Engineering

A community's lifelines, those systems for water, waste disposal, energy, transportation, and communication, are prime candidates for protection against natural and other hazards. They represent vast investments and in severe disasters can be the Achilles' heel of a stricken area.

"Lifelines engineering" is a term primarily developed in connection with dangers to these systems arising from possible earthquakes, but it also has broader applicability to other hazards. The significant attention given to lifelines engineering by the American Society of Civil Engineers with the creation of its Technical Council of Lifelines Earthquake Engineering is evidence of increasing professional concern which these systems are receiving.

There are three major lifelines problems that may be caused by disasters. First, an area may suffer long-term disability through the loss of power, disruption in energy sources, and disabled or destroyed transportation, sewer, and water (including irrigation) networks. Second, a community's ability to deal with disaster events can be seriously affected by loss of water to fight fires, reduced effectiveness in aiding the injured because of damaged roads and powerlines, and risks to health caused by damage to water and sanitation systems, food supplies, etc. Finally, problems arise because of interagency and intergovernmental coordination required for providing services through both private and public ownership of lifelines systems, the regulation of such facilities, and determining the responsibility for safety of lifelines and of residents of communities where key facilities are located. These present extremely complex situations affecting achievement of hazard mitigation compatible with community needs and other public services and systems. The recent example at Pennsylvania's Three Mile Island is illustrative, even though it was not a natural disaster.

With the increasingly fragile nature of our urban communities and the advancing complexity of our lifelines systems, major disruptions in the services they provide can create disastrous events in instances that once would have produced only minor discomfort.

The technology for reducing the impact of natural hazards on lifelines systems is available in many cases. It can be expensive, illustrated by the cost of back-up equipment and "redundancy" desirable in certain facilities and often urged by engineers. State government initiative may be needed to seek application of safeguards, effective regulation, inspection and enforcement, and other actions likely to be required at all three levels of government.

Safeguarding Critical Facilities

In addition to lifelines, other critical facilities—such as schools, hospitals, dams, etc.—also present special challenges to hazard reduction planners. They, too, often require a mix of private and public controls and actions which cut across all governmental levels. Many measures which can reduce the impact of natural hazards on these critical facilities are now known to exist. Hazard delineation and assessment, for example, can aid in the safe siting of many

facilities. Building technology, sometimes oriented to specific hazards which have been experienced or can be anticipated, may help make them disaster resistant. Other technological advances can help provide improved warning and back-up energy generating systems.

A special word is warranted on behalf of state actions to assure the safety of dams, particularly those on private property which may need to be dealt with by use of police power vested in state and local jurisdictions.

In August 1972, a national program for inspection of nonfederal dams was authorized when Congress passed the National Dam Inspection Act. The act authorized the Department of the Army (through the Corps of Engineers) to inspect nonfederal dams, generally those 25 feet or more in height and impounding more than 50 acre-feet of water. An inventory of about 50,000 of these dams was completed by May 1975, but funds for inspecting the dams were provided with enactment of the 1978 Public Works Appropriation Act only after several dam failures had occurred.

An inspection program was begun in 1978. During the first year, 354 out of 1,793 dams inspected were found unsafe; emergency actions were deemed necessary in view of the possible failure of 26 of these dams. The cumulative total of unsafe dams reported through March 1979 was 619.

The Corps of Engineers has concluded that a nationwide problem of unsafe dams does exist; although 40 of the 53 states, commonwealths, and territories have effective dam safety legislation, only 20 states have the capability to perform or administer their own dam safety programs.⁵

States are concerned not just with nonfederal dams but also with those of the federal government located within their boundaries. Responsibility for planning and coordinating dam safety programs rests with each of seven major federal agencies involved in some aspect of dam construction, licensing, regulation, financing, etc. The director of the Office of Science and Technology Policy was asked by the president to review federal agency safety regulations and practices; that office has done so and made a report.⁶ The dam safety coordination role performed by the director's office is being assumed by the Federal Emergency Management Agency.

The Secretary of the Interior has recommended that the Federal Emergency Management Agency take leadership in identifying means by which states can be encouraged to develop effective dam safety programs. He suggested that legislative initiatives be considered as well as federal incentives for state involvement. He also suggested that a mechanism be established in the Federal Emergency Management Agency for monitoring and evaluating the continuing effectiveness of state dam safety programs.⁷

The Secretary of Agriculture is urging the Corps of Engineers to support the states in developing strong state programs and indicates that the Department of Agriculture will provide assistance, probably through the Forest Service and the Soil Conservation Service.⁸ The federal government recognizes that it has historically fostered many private dams through various kinds of assistance, but that it has failed to provide mechanisms necessary to assure their safety. The need

for such mechanisms is apparently a problem which state governments must face, possibly with federal assistance.

A dilemma for the states is presented by the fact that private dam safety may well be a problem, one where the federal inspection program will continue to call the states' attention to dams believed to be hazardous and in need of state action. But states are also faced with other hazards and other critical facilities which need their attention. This demonstrates that states must determine priorities and relationships among hazards and hazard-mitigation measures in developing comprehensive hazard mitigation programs.

Preparedness for Response to Natural Hazards Disaster Events

Response readiness and responding to natural hazard disasters are the phases of emergency preparedness to which states have given the greatest attention. Mitigation of the impact of disaster events and contending with emergency situations are, of course, the goals of these efforts. In fact, some state officials, when describing their mitigative activities, mostly confine their observations to efforts applicable to the response phase of emergency management programs. This is a situation also noted in recent studies of the National Governors' Association.

Preparedness and response planning has accordingly received more extensive attention in state government than most other aspects of comprehensive emergency management. It is a complex phase of disaster program management because all three levels of government may be involved and many federal, state, and local agencies conduct functions concerned with disaster response and post-disaster assistance.

A prime key to maximizing effectiveness in this hazard-reducing effort is the availability of predictions and forecasts. These govern both warnings issued and suggestions made for community and individual protective actions. Yet states must face the fact that the ability to predict disasters is ranked generally low for most of the 14 natural hazards identified earlier in this chapter. Progress is being made in the ability to predict some of these hazards and the increasing ability to delineate hazards will bring greater predictive capabilities. Efforts of the National Weather Service, aided by its use of sighting volunteers and other new developments, are contributing to improved prediction of floods, hurricanes, tornadoes, windstorms, and winter storms. A tsunami warning system in the Pacific is increasingly reliable. Geophysicists and other scientists engaged in earthquake prediction foresee slowly evolving improvement in the prediction of earthquakes. The U.S. Geological Survey is closely following earthquake predictive progress in other countries, particularly China, Japan, and Russia, and has stepped up the nation's efforts to better understand seismic activity in the central and eastern sections of the United States, primarily where high magnitude earthquakes have occurred before. Federal and state geologists largely use historical and geological observations, and the U.S. Geological Survey has in the past two years sought to create better arrangements in its communications with the states. The National Oceanic and Atmospheric Administration has cooperated in this effort.

There are many matters of special concern to those responsible for disaster preparedness and response programs. Among these are warning systems and facilities, communication systems, inventories of supplies and equipment needed for response efforts, evacuation plans based on best-available facilities, response plans to deal with unique requirements in certain kinds of disasters, and the promotion of public understanding and knowledge of the effect of natural hazards on communities and their residents.

Response plans must be closely linked with the planning required for other phases of comprehensive emergency management which are more likely the concern of other federal, state, and local agencies rather than those responsible for the disaster response mechanism. Unless this relationship is close, response efforts at the time of a disaster may not be as effective as they should be; in fact, they may actually hamper longer-range, socially desirable objectives.

Disaster response officials also have need to keep abreast of new technology applicable not only to their own efforts but also those for other hazard reduction measures.

The role of state officials in evaluating the capabilities and the performance of state and local agencies in disaster response is one where state responsibility has not always been consistent. Disaster response planning has been undertaken in all states, but such planning may not encompass the essential elements of a complete planning effort, as identified in Chapter 2. Admittedly some of these elements extend beyond the normal tasks of a state emergency services agency; it is for this reason that each of the organizational alternatives discussed in Chapter 4 encourages participation and communication among the various agencies and officials that play central roles in a comprehensive state emergency management program.

Long-Range Recovery

Short-range recovery measures, likely to be taken after the occurrence of disaster events, may re-create situations under which disaster events could be repeated, with similar results.

Long-range recovery should, on the other hand, be based on more carefully planned actions which would incorporate hazard reduction measures as a means of avoiding similar loss and damage in the event future hazards visit the same location. Such planning, deemed largely socioeconomic in nature, could bring long-range benefits to areas whose future development merits basic reconsideration if disasters bring great destruction. Some of the considerations relate to opportunities for rebuilding in different ways, desirable resettlement, new approaches to land use, and the like.

This phase of a comprehensive emergency management program was singled out for attention in the report of the Senate Committee on Governmental Affairs, mentioned in Chapter 2. It is to be hoped that further attention to long-range recovery by the Federal Emergency Management Agency will help clarify federal, state, and local roles in this phase of emergency management. All three levels of government should benefit if soundly based recovery efforts can be

developed that will recognize the economic potential and usefulness of areas which have often suffered the ravages of natural hazard disasters but have lacked the economic base for achieving maximum future utility. Such an objective is one likely dependent on basic reexamination and change.

Other Hazard Reduction Measures

There are many additional hazard reduction measures available for use by state and local authorities. Some of these, such as federal flood insurance, are obtainable under conditions of federal law; others no doubt will be developed or extended as the value of hazard mitigation receives greater recognition and as hazards continue to threaten more people and property.

Forbes Magazine (October 1, 1977) said that the federal flood insurance program is "drowning in a sea of argument." A slow beginning and possibly an uncertain future may face this program, but it admittedly has facilitated improved floodplain management in communities obtaining eligibility for federal flood insurance. Private insurance companies offer other protection, ranging from coverage for fire and wind to earthquakes and tornadoes, although some are not widely utilized. The effectiveness of these programs is variable and uncertain, especially as more costly disasters create situations of higher premiums and possible unavailability of coverage. One solution which has been suggested would be the enactment of a federally subsidized disaster insurance program, where the government would levy a surcharge on all property and liability insurance premiums written in the country. Recognizing that such a program is highly controversial, some claim it would, however, cost less than taxpayers now spend for federal disaster aid. States could presumably move in these directions even if the federal government does not.

The availability of insurance to cover losses from disasters may conceivably expedite rebuilding or restoration of the same facilities in locations where previous disasters have occurred. In the long run, this is a result which could be disadvantageous. Similarly, insurance coverage has in some cases stimulated occupancy of hazardous locations that otherwise would likely not have been used.

It is also evident that complete relaxation of efforts to mitigate hazards by hiding behind a wall of insurance protection would not be in the common interest. A few may be provided with economic protection, but threats to life and property would still remain. Furthermore, cost effectiveness is an issue to be examined because insurance premiums, in an overall sense, will have to cover not just the value of property losses but also interest, profits, and administrative and overhead costs as well. The cost of such insurance can, in fact, be properly viewed as a part of the loss attributed to hazards.

Other hazard reduction measures are possible, many of which could utilize the police power of the states to protect the health and safety of workers and others, to protect the environment, and to promote conservation. Such goals carry higher objectives in government programs now than in former years. Regulatory powers can conceivably be used, for example, to protect workers on

projects located in potentially hazardous areas, such as avalanche pathways, areas of subsiding land, etc. Public responsibilities to look out for the well-being of citizens through measures to assure air and water quality, protection of animals and aquatic life, and safety of food supplies are not taken lightly. Hazard mitigation measures in these categories may have greater applicability to man-made hazards than to natural hazards.

Other hazard reduction measures could proceed from the desire of public groups to protect consumers. Examples of this are requirements to assure that purchasers of land and other property are aware of potentially dangerous soil conditions and geologic structures that could lead to landslides and avalanches, and possible damages in the event of earthquake tremors and flooding.

Appraising the Feasibility of Hazard Reduction Measures

It is one thing to identify potential hazard reduction measures such as those described above, and another to effectively mitigate the impact of natural hazards. Appraising the feasibility of mitigation measures raises somewhat different questions involving matters such as effectiveness, reliability, social acceptability, and environmental impact. These, too, are factors which both analysts and decisionmakers must take into account.

Most of the hazard-reduction measures described above have been recognized as ones which can be effective though each measure may not necessarily be effective in every situation. For example, a dam or reservoir to help control danger from flooding may encourage construction of housing and other buildings on land that would be severely flooded if the dam failed due to an earthquake or other geologic factors.

It is known that although certain so-called earthquakeproof or floodproof structures have survived earthquake tremors of a given intensity or floods reaching record flood stages, there may be bigger earthquakes and larger floods. Determining how reliable a hazard reduction measure will be if two different hazards occur simultaneously, possibly accompanied by human errors related to essential facilities and services, are realistic conditions to be considered.

Social acceptability often does not support zoning restrictions on land use, and it is this factor which so often influences elected officials who have to make zoning decisions on property owned by persons who believe they have the right to do whatever they wish with property which they own. Social acceptability, as officials well know, works both ways in instances of this kind. Religious beliefs which characterize natural disasters as "acts of God" often, in communities where such beliefs are widely held, make it popularly or politically infeasible to adopt restrictions that otherwise could reduce the destructive impact of natural hazards. Social acceptability is also related to costs, and while cost-benefit studies can be helpful, they do not necessarily provide politically acceptable answers.

Environmental impact, thought by many persons to be an impediment to progress, is nevertheless a factor to be appraised in evaluating hazard reduction measures. It is evident in these days that many historically recognized flood

control measures such as concrete stream channels, other channelization of streams, and many dams may now be considered environmentally unsound. On the other hand, measures such as the use of seismically active areas for nature preserves or parks may be deemed wise from an environmental point of view.

Consideration of judgmental factors such as those singled out above should be part of an analysis of hazards and mitigation measures. They will affect decisionmaking by both administrative and legislative decisionmakers and, consequently, should be taken into account by planners and analysts concerned with comprehensive emergency management. This does not imply that analysts should make judgments which should properly be made by policy officials, including those in the executive structure and those who are members of legislative bodies. It is the job of the hazards analyst and program developer to present alternative courses of action and information that will assist choices to be made by those with the responsibility for making them. This kind of presentation is the essence of the analysis and program assistance needed in the management process described below.

Programming and Budgeting for Hazard Reduction

Many effective public administrators point out that public business is best accomplished by the use of systematic approaches for getting it done. Otherwise, in state government, for example, gubernatorial leadership may lack the opportunity for fulfillment of objectives; may be negative instead of positive; state agencies may go "their own ways"; and public employees may behave in a rudderless government, like the maligned "bureaucrats" they are often accused of being.

If a governor wants to assert leadership in the mitigation of dangers from natural hazards and avoid or minimize emergencies, a well-developed system for fulfilling the objectives of a comprehensive emergency management program may be needed.

It is for this reason that the organizational alternatives set forth in Chapter 4 place emphasis on fixing responsibility for the development of annual or biennial natural hazards programs, with the breadth and inclusiveness of such programs to be determined.

Elements of a system for implementing hazard mitigation activities should include, in addition to measures that can be effective in reducing injuries and deaths and minimizing or preventing property damage and loss, steps to initiate those activities. All of this must be budgeted, and appropriations enacted or other sources of funds sought and obtained.

Hazard reduction programs and measures will include both operating activities and capital improvements. States have different ways of developing and approving budgets, also of obtaining funds. Decisions must be made on how to combat emergencies in the light of other state practices.

Because fulfillment of the goals and objectives of emergency programs is likely to include program and budget development by many state agencies, special cross-cutting budget analyses and reviews, bringing together both

prospective operating and capital costs of such agencies, may be desirable in order that comprehensive emergency program elements can be viewed in their entirety and priorities can be more readily determined. Special budget review sessions may be warranted, and special presentations may be desired for gubernatorial messages to legislative bodies.

The administrative mechanism most suitable in each state depends on the state. It may consist of the governor and his central aides in consultation with legislators and their committees, possibly also with representatives of local jurisdictions and federal agencies. Because major hazard reduction measures will involve shared approaches, funds from various sources, and decisions at different levels of government, states may find merit in ensuring that their administrative procedures take these into account. The way in which a state organizes for goal setting, programming, decisionmaking, and conduct of intergovernmental arrangements is pertinent, as are the interrelationships among different kinds of hazards, emergencies, and disaster management activities. The following chapter seeks to consider some of these matters in a way that recognizes the complexities and perspectives involved.

Footnotes

1. J. H. Wiggins Co., *Building Losses from Natural Hazards: Yesterday, Today and Tomorrow* (Redondo Beach, Calif.: 1978). The nine hazards encompassed in this report are earthquake, landslide, expansive soil, hurricane wind/storm surge, tornado, riverine flood, local wind, local flood, and tsunami.

2. Peter H. Rossi, James D. Wright, Sonia R. Wright, and Eleanor Weber-Burdin, "Are There Long-Term Effects of Natural Disasters?" *Mass Emergencies* 3 (1978), p. 128.

3. Ian Burton, Robert W. Kates, and Gilbert F. White, *The Environment as Hazard* (New York, N.Y.: Oxford University Press, 1978).

4. The Council of State Governments, *A Legislator's Guide to Land Management* (Lexington, Ky.: 1974).

5. Department of the Army, Office of Chief of Engineers, *Inspection of Non-Federal Dams: First Year's Progress* (Washington, D.C.: 1978).

6. Office of Science and Technology Policy, *Federal Dam Safety Report of the OSTP Independent Review Panel* (Washington, D.C.: 1978).

7. Department of the Army, *Inspection of Non-Federal Dams*.

8. *Ibid.*

4. Implementing a Comprehensive State Hazards Program

What are some of the things which a state government should consider in seeking to achieve an effective state natural hazards program—one concerned, comprehensively, with hazard mitigation, disaster response, and post-disaster recovery? What issues need to be dealt with in developing a capability to undertake tasks discussed in the preceding chapter of this report?

The first of several implementation issues considered below is that of organizing state government to do the jobs that need to be done. Only through the establishment of a workable organizational structure can responsibility be fixed for each of the several stages in disaster program management. Provision can then be made for necessary executive direction and coordination of the many participants who will be engaged in those programs.

In addition to organizational structure, this chapter singles out three other general issues relevant to a state's implementation efforts. First, the state's relationships to its local jurisdictions and regional (substate) bodies should be considered. The state should fulfill a leadership role in relation to local jurisdictions within its boundaries. Reasons for this are similar to those which call for national leadership by the federal government. In addition, local jurisdictions derive their powers from state government.

The second issue, and one of major concern to state and local officials and of increasing significance in the administration of many public programs, is the potential liability of officials in the performance of their duties. These duties relate to issuance of warnings, dissemination of data on potential hazards, and taking or not taking actions concerned with hazard abatement and mitigation. There may be needed, in these days of greatly increased litigation, legislation to immunize officials so that they are not inhibited from taking measures for protection of the public.

The final issue that will have to be faced by state and local governments is the result of anticipated greater attention to hazard mitigation—namely, assuring the availability and obtaining the kind of personnel resources that will be needed to plan and develop hazard reduction policies and programs. This issue is one of concern to the new Federal Emergency Management Agency.

STATE ORGANIZATION FOR A COMPREHENSIVE HAZARDS PROGRAM

States need to take a fresh approach to organization in fulfilling the objective of a comprehensive hazards program. In the past, most states have limited their organizational considerations to the response phase of disaster program management. This is no longer adequate if a comprehensive program is

to be achieved, particularly if the federal government puts emphasis on disaster mitigation as called for by its new policies.

This report does not contend that any single organizational structure can best meet the needs of each state, territory, or jurisdiction. Alternatives are in order in these considerations, and are presented below.

Based on factors discussed in Chapter 2, one generalization will be respected—that whatever structure of organization is developed for a state's natural hazards program, it should be one that maximizes the use of the powers of the chief executive as a means of ensuring greatest organizational effectiveness. Some states can do this more easily than others, depending upon the administrative powers granted to the governor by state laws.

Also in accord with an earlier part of this report, it is recognized that states as well as local jurisdictions and the federal government should adhere to the concept that public functions under emergency conditions can usually be best performed by whatever agencies handle these functions on a nonemergency basis. Consequently, many state agencies will be involved in emergency programs, and organizational arrangements should necessarily take this factor into account.

To illustrate alternative approaches to organization, three hypothetical cases follow. None of these arrangements may exist or apply exactly as described in any one state. Numerous alternatives within and among these several arrangements will be evident to state officials and others knowledgeable about state government organization and functions.

State A (Most state functional responsibilities and appointive powers vested in governor)

In this hypothetical state, the governor has an executive office, distinct from his personal office, to which are assigned the managerial assistance functions that help him lead the state as its chief executive. The executive office performs functions related to organization and management planning, budgeting, planning or policy development coordination, emergency services, intergovernmental relations, finance and accounting, personnel management, and possibly other general services (e.g., procurement and property management, services related to general-purpose state buildings, and central services of various kinds). These are functions which do not deliver services directly to the public but which deal across-the-board with state management and administration and with all or at least most operating agencies of state government.

The governor also has in his personal office an aide whom he wants notified immediately about any emergency or disaster which requires the governor's personal attention or should at least be known to the governor when it is impending or occurs.

Looking more specifically at natural hazards program management, the governor's emergency services agency is charged with the job of maintaining readiness to respond to natural disasters and of leading the state's response

efforts when a natural hazard event occurs. It is also concerned with preparedness and response for civil defense and other kinds of emergencies. It makes use of all state departments and agencies which have roles to play in any emergency to which it may have to respond; it maintains contact with and assists local jurisdictions in disaster response matters, making full use of the state's community affairs agency; it operates a warning and communication system and maintains various facilities and equipment, not otherwise available, used in responding to disasters; and it handles applications to the federal government for federal disaster aid when major disaster events occur.¹

Recognizing that hazards mitigation is largely inseparable from the regular, nonemergency missions of state departments and agencies, the governor has assigned the job of providing central coordination on his behalf in the development of hazard mitigation policies and programs to the state planning office because it is this office to which he looks for coordination of policy development and planning for state programs in general. He also looks to the head of the planning office to provide leadership on his behalf in long-range planning for post-disaster recovery programs; this is a kind of planning, strongly economic in nature, which is not unlike other tasks of the state's planning office. Land use and growth policy, economic development, building codes and regulations, natural resources, public utilities, and environmental and other state programs—and the agencies administering those programs—will all be involved in both hazards mitigation and post-disaster recovery stages of the state's comprehensive disaster program.

Several possible choices had been considered by the governor in selecting an official who would represent him in seeking coordination of the many agencies involved in administering the three stages of the state's comprehensive disaster program—mitigation, response, and recovery. He could have chosen the staff assistant in his personal office who keeps in touch with hazards events; but, for institutional management reasons, consideration centered principally on the director of administration and the planning office head. The latter was finally chosen, and he was given the additional (ex officio) title of the Governor's Liaison Officer for Emergency Management.²

The governor considered the emergency services director a less appropriate choice for this role because, as the state's key civil defense official, he was stationed at a fallout-hardened location not near the governor's office and, in addition, he was not closely identified with the governor and his administration. He is deemed by the governor more action-oriented, less planning-oriented and, consequently, was not viewed as the best choice for a post closely identified with tasks of coordinating planning and management functions for and on behalf of the governor. The governor's planning office staff is regularly engaged in analytical assignments involving coordination of state agencies and functions. Tasks concerned with the coordination of natural hazard programs were deemed similar to these other assignments.

In order to bring together the principal state officials who would be involved in various aspects of the comprehensive emergency management program, the

governor also created an emergency preparedness program committee comprised of his planning officer as chairman, the state budget director, the emergency services officer, and the head of the state community affairs agency. Because of the importance of federal grants in the committee's considerations, the state's chief federal grants liaison officer also participates with the committee. In addition, the governor directed that the committee, when considering matters of special interest to local government, should be joined by three representatives serving as contributors and observers from the state's municipal league, the association of counties, and the association of substate planning organizations. The governor indicated that the committee should give special attention to policy and program recommendations for inclusion in annual or special gubernatorial messages and in state budgets, and that he would meet with the committee if it would be helpful to the policy formulation processes of his administration.

State B (A cabinet-type structure with limited functional responsibilities and appointive powers vested in governor and his appointees)

The governor in this hypothetical state has less authority over many of his state's departments and agencies than that of the governor in the previous example. In his state the performance and management of department and agency functions are vested by law not in the governor but in the directors of the departments and agencies and sometimes in subordinate division heads within departments. He also lacks authority to appoint officials responsible for directing many departments and agencies, especially those with fixed terms or those appointed to overlapping terms on multiheaded commissions.

He does have authority, however, to appoint secretaries for many broad-ranging state functions (e.g., transportation, human resources, natural resources and environmental services, public safety, and the like). These appointees advise the governor on his administration's policies in their respective functional areas. They have authority to request assistance from and are in communication with the heads of departments and agencies carrying on activities related to the broad general functions assigned to them. Each of the secretaries is looked upon as the governor's man. Collectively they constitute a cabinet utilized by the governor in exercising leadership on behalf of the chief executive.

The governor also has an executive office somewhat similar to that in the previous example, but it lacks a planning, policy development agency, largely because functional planning is undertaken in planning staff units established by each of the several secretaries in his cabinet. The executive office is headed by a secretary of administrative affairs and includes a state budget and finance officer as well as other officials engaged in various statewide administrative services. The executive office includes a federal grants officer and a community affairs agency. The former maintains a close relationship with a small Washington-based federal liaison staff as well as with state agencies heavily involved with grantsmanship. The latter agency maintains relations with municipal and county governments in the state, with substate planning organizations, and it provides a number of state services conducted for the benefit of and to assist local jurisdictions.

The emergency services officer, responsible for traditional disaster response and civil defense activities, heads an independent emergency services agency. He looks to the governor's secretary of public safety for general guidance. He maintains a liaison relationship with a designated aide in the governor's personal office relative to imminent or existing disaster events.

The governor designates his secretary of natural resources and environmental services to develop a comprehensive disaster management program for his state and gives him the additional (ex officio) title of the Governor's Liaison Officer for Emergency Management. As in the previous case, the governor establishes an emergency preparedness program committee, chaired by the secretary of natural resources and environmental services. The committee's membership includes the state budget director, the emergency services officer, the head of the community affairs agency, and the state's federal grants liaison officer from the state office of federal-state relations. A planning assistant to the secretary of natural resources and environmental services acts as secretary to the committee and takes the lead role in staff work needed to develop and compile a comprehensive state natural hazards management program. In other respects the committee is not unlike that previously described.

State C (A state putting emphasis on a single natural hazard of special concern)

When the governor took office, he found a somewhat different setting for natural hazards programs in this third hypothetical case. The legislature had responded to the concern of many professional people, local officials, and residents who believed the threat of major earthquakes justified special organizational attention in state government. In recognition of the tectonic structure of the earth's crust within the state and the state's seismic history, it had created a Seismic Safety Commission comprised of members appointed by the governor and confirmed by the state senate. Members were selected from the state's legislative and executive branches; from the ranks of professional geologists, engineers, and sociologists of universities in the state; and from representatives of both local government jurisdictions and statewide citizen and professional organizations.³ This commission, with an executive director and a small staff, was serving primarily as the state planning agency for policy development on seismic safety issues. The commission had the job of advising the governor and the legislature on goals and priorities for earthquake hazard reduction and on related state agency budgets and programs. It sponsored training, encouraged research, examined intergovernmental roles and relationships and, with its own staff and members and representatives from other state and local agencies, conducted studies of specific problems. Among these were statewide hazard abatement, seismic safety of state-owned buildings, the need for dam inundation mapping, nuclear power plant location, and local government implementation of state earthquake hazard reduction legislation.

In addition to the Seismic Safety Commission, the governor's organization includes an emergency services agency whose director is responsible directly to the governor. This office, concerned with response readiness for natural hazards

of all kinds, also has a special staff and an advisory body concerned with earthquakes. The state law specifically authorizes and requires certain action with respect to earthquake events. These include pre-earthquake preparation and warning, evaluation of post-earthquake operations, and recommending the designation of areas to be included in any earthquake emergency proclamations issued by the governor.

The state law places in the governor the responsibility of issuing warnings of impending earthquakes to state residents, and this responsibility is one of concern to the emergency services agency which assists him in these matters. It is pointed out in the Special Section of this report that the prediction of an earthquake can itself trigger an emergency situation meriting response by public officials and, in fact, presents an opportunity to take mitigative actions which otherwise might not be taken. As outstanding scientists have advised, progress in the technology of earthquake prediction may well advance to the extent that a "time-window," even up to several years, may be identified between the prediction of an earthquake and the occurrence of an earthquake. The prediction of a potential earthquake may signal a need that the governor issue an earthquake warning to his constituents; the nature of the warning will vary depending upon the "time-window."

To enable the governor to proceed with caution, the emergency services agency in the state has established a state earthquake prediction evaluation council chaired by the state geologist and including seismologists, geologists, and geophysicists from universities and consulting organizations who are knowledgeable about the state's geologic structure. This council and the emergency services office have also established liaison arrangements with the U.S. Geological Survey and its earthquake prediction council (proposed now to become the National Earthquake Prediction Evaluation Council) in order to have access to the best information on earthquake precursor data, indicators, and advice which can be obtained from other sources. It is the task of the state's evaluation council to evaluate individual earthquake predictions and to advise the governor as to their evaluation. Although the scientists may predict earthquakes and may evaluate predictions made by scientists and others, it remains the responsibility of government officials to issue warnings to the populace, accompanied by whatever instructions are appropriate in order to maximize community safety and to prevent injury, loss of life, and economic damage. Ultimate responsibility is the governor's, even though chief executive officials of local jurisdictions and officials of other state and local agencies may well be involved.

In order to ensure that their efforts to reduce earthquake hazards are effectively tied in with hazard mitigation efforts applicable to other natural hazards and with other emergency management efforts in the state, the governor asked his state planning officer to chair an emergency preparedness committee having a mission similar to those of the committees discussed in the two previous examples. The executive director of the state's Seismic Safety Commission serves on the committee along with the emergency services officer, the state budget

director, and the head of its community affairs agency, with the federal grants officer from the state planning agency sitting in on occasion. Planning aides in the state planning agency give attention to policy development and coordination for other potential hazards similar to that performed by the staff of the Seismic Safety Commission in regard to earthquake hazard reduction. The planning agency is also assigned the responsibility for developing a comprehensive emergency management program.

Other organizational arrangements, involving the need for coordination of state agencies and officials and for effective relationships with federal and local levels of government, are much like those described previously.

Summary

This report may appear to put more emphasis on having an emergency preparedness committee made up of state officials (perhaps with representatives of local jurisdictions and substate agencies) than is warranted by the faith in such committees commonly held by many practitioners of public administration. Reliance on such committees may not be warranted despite the emphasis placed by the Senate Governmental Affairs Committee on the committee created in the federal government (see Chapter 2 of this report). Staff of the Council of State Governments has not always found enthusiasm for such committees in the executive branch of the federal government, and enthusiasm may not even be shared by busy members assigned by the president to the new Federal Emergency Management Committee. Also, there may not be enthusiasm among members of similar committees established in state government.

However, suggesting the establishment of such committees carries a significant message—coordination is needed that necessarily involves the authority of the governor and, therefore, involves the aides who help him discharge that authority. Even if such committees are not created and utilized, there is the need that responsibilities be clearly assigned, accompanied by some sort of systematic process and schedule that helps to assure their fulfillment. There will also be need for consultation among the agencies, personnel, and officials involved, whether or not there is a committee. Decisions on a comprehensive natural hazards program or on a broader comprehensive emergency management program should not be made in a vacuum. Appropriate consultation and participation with and authorization and support from both chief executives and legislative bodies are needed. For comprehensive hazard programs, the results sought should be those which demonstrate that hazard mitigation is a cost-effective, hazard-reducing substitute for post-disaster aid.

AUTHORITY AND ASSISTANCE FOR LOCAL HAZARDS PROGRAMS

Because the existence and the powers of local jurisdictions are dependent on state law, state government has special responsibilities to those jurisdictions within its boundaries. These responsibilities are especially acute in the case of natural hazards and other emergencies which threaten the lives and property of their residents.

State government is involved with its local jurisdictions in at least three important aspects of hazards management.

First, natural hazards do not respect jurisdictional boundaries. Disasters which can occur in one area may call for mitigation actions elsewhere. Even in response and recovery efforts after disaster events occur, interaction among jurisdictions may best be approached with the help of state government through interstate compacts or intergovernmental agreements.

Second, few if any local jurisdictions are self-sufficient in meeting the needs of their residents. While variations exist among the states, many essential services which must be reckoned with in hazard mitigation planning and which are utilized in emergency response situations are provided by state agencies or financed in whole or in part from state and federal funds. This is particularly applicable to many state health and other social services which not only have general applicability to people who may be distressed in emergency situations but which, along with income maintenance programs, have special relevance to persons in low-income brackets, those likely to suffer most severely when disasters occur.

Third, state government provides the essential linkage to the federal government for those emergencies which have interstate, national, or international origins or impacts.

State governments, through their emergency services and other state agencies, provide continuing assistance to local jurisdictions in allocating federal civil defense/disaster funds to those jurisdictions. They also allocate federal pass-through grants as well as state funds for local administration of key local activities, some of a planning nature, others involving actual service delivery.

Hazards Mitigation in Local Government

County and municipal employees identified as civil defense/disaster officials, partially financed by federal civil defense grants, are generally concerned with response to disaster events and less concerned with disaster mitigation or long-range recovery in stricken areas. Attention is more likely given to mitigation and to post-disaster recovery at local government levels by those officials concerned with land use planning, building regulation, public works, utilities, and other relevant services.

At the Council's 1977 Conference on Earthquakes and Related Hazards, the point was made that:

The traditional types of measures of preparedness (i.e., for responding to the event of a disaster after it occurs) are an important part of what will happen in the event a long-term (earthquake) prediction is issued, but they are only a small part of an effective, comprehensive mitigation program. . . . Effective hazard reduction measures are critical for emergency preparedness. City planning directors, attorneys, and others will make as many of these decisions, likely more, than disaster directors.⁴

A leader among scientists who have examined socioeconomic implications of earthquake prediction also echoed this point in testimony before the Senate Committee on Commerce, Science, and Transportation, held on the bill which became the Earthquake Hazards Reduction Act of 1977:

Civil defense and sheriffs and police departments take the lead in emergency planning and emergency response. Their emergency roles are designed to make good use of their skill and experience in restoring order and responding to crises instantaneously. But hazard reduction in advance of a predicted earthquake is remote from their usual role of activity. Planning departments and building and safety departments, on the other hand, are accustomed and equipped to deal principally with hazard control in the long range.⁵

State and federal assistance for local hazard mitigation and disaster recovery efforts are generally limited to construction aid aimed at specified purposes. Hazard mitigation is often only an indirect concern.

Although city and county planners can assist in determining hazard mitigation policies and programs for their communities, few local planning commissions and agencies have undertaken these activities. Most are more concerned with zoning and subdivision regulations. Although some are concerned with more comprehensive master plans, few of those plans encompass hazard mitigation. California's mandate for inclusion of a seismic element in a local government's "general plan" is an exceptional requirement, and the accomplishments are inconclusive. Floodplain conditions are the most likely element to be taken into account by local land use plans and here results are spotty and inconsistent.

Impetus toward planning, programming, and budgeting systems (PPBS) in the 1960s heightened awareness that cities and counties have a program planning role as well as a role in planning for land use and capital improvements. New federal approaches to Management-by-Objectives (MBO) and Zero-Base Budgeting (ZBB), accompanied by similar efforts in many state and local governments, have not yet adequately developed doctrine or defined roles and relationships of planners and budget analysts or of processes for planning and resource allocation. Evolutionary developments in these processes, however, point toward a gradual delineation of management systems which may ultimately be more universally useful in the development of state and local natural hazards policies and programs. State and federal examples and leadership can facilitate the development of such management systems which can be useful to local government.

The most notable exception to a general lack of planned hazard mitigation activity at local government levels may likely be that associated with seismic risk concerns in a number of California's local governments. A recent effort by the city of Los Angeles, heralded as the first comprehensive study on earthquake prediction undertaken by a municipal corporation, produced a report to the mayor covering many aspects of seismic safety.⁶ There have been other efforts in some California municipalities; notable among these is Long Beach's development of a program to identify its most hazardous buildings. But even in jurisdictions that have experienced earthquakes, community support for significant change in land use patterns has not been demonstrated.⁷

In many respects, the role of local jurisdictions in this shared partnership with state and federal governments is the most difficult one. Chapter I noted the lack of community support for allocating local financial resources to costly measures for alleviating invisible or intangible risks. Of major significance are the

political realities involved in the hard decisions, basically made by elected officials on city councils and county boards, on how land in private ownership can be used and on what safety regulations, which would add to building costs, should be mandated. Other observations on local hazard mitigation measures were described in Chapter 2.

A University of Massachusetts study has pointed out: "policies designed to deal with the national disaster problem and which appear to be rational and effective from that viewpoint, may be seen as burdensome, irrational, inefficient, and perhaps even counter-productive from the viewpoint of communities to which they are applied." Citing the federal flood insurance program as an example, the report said, "From a federal viewpoint, the program has much to recommend it. From the viewpoint of a specific community whose memories do not contain a hundred year flood, the policy may appear to be capricious and inequitable. From the federal perspective, hundred year floods occur every three months, with four or five such floods occurring each year over the nation as a whole."⁸

Local public administrators have long recognized these problems. They generally know the kinds of measures, if not the specific ones, which should be taken. More than 50 years ago, with floods, earthquakes, landslides, and other natural hazards in mind, Louis Brownlow, certainly one of the twentieth century's most noted exponents of strengthening public administration, wrote:

To that I say that the community by its organized activities does not ignore these factors. It endeavors ceaselessly to overcome them, postpone them, influence, modify, and mitigate them. The Tokyo building code has an eye for the mitigation of the effects of earthquakes; Dayton rebuilt itself spiritually as well as physically by attempting to prevent a recurrence of its flood disaster; and now we see the levee system of the Mississippi that began with a communal dike at New Orleans, then grew into state systems of levees.⁹

These views point to the importance of state and federal roles in achieving hazard mitigation. Neither Dayton nor New Orleans solved their flooding problems without state and federal assistance. Today, both the federal flood insurance program's requirements, calling for land use controls in floodplains, and California's Special Studies Zones Act, requiring delineation of hazardous fault zones and establishing certain regulations governing approval of proposed projects and disclosure relating to property being sold in such zones, are examples of federal and state leadership which is producing effective hazard mitigation at local levels, even though not always with wholehearted community support.¹⁰

From an administrative point of view, local government efforts on behalf of hazard mitigation will be dependent, as they are at state and federal levels, on the constructive use of executive powers to guide local agencies in the performance of their regular functions. Even then only the larger cities and counties are likely to have the technical skills to pursue such objectives.

In the final analysis, local government effectiveness may depend largely on how well a city manager, a county executive, or a mayor recognizes and performs the emergency aspects of his managerial responsibilities.

Use of Regional (Substate) Planning Agencies

Planning for the mitigation of natural hazards offers another avenue whereby states can be of assistance to their counties and cities.

Regional or substate planning agencies exist in all but a few states. These agencies often are better able to look at disasters and emergencies on a broader geographical basis than can the local jurisdictions within their areas. In addition, where counties or municipalities are too thinly populated or are too small to warrant employment of the kind of technical personnel needed to deal with such essential planning and service functions, regional bodies can, if so authorized by law or requested by their member jurisdictions, meet this need.

The range of hazard mitigation activities in which some of these regional or substate planning agencies in the United States have been engaged has been impressive. Successful activities include planning for coastal zone areas, provision of information and systems for control of upstream runoff into lower-level floodplain areas, and development of regional natural hazard mitigation programs. But it is evident that in most states the potential of these regional agencies is far from being realized.

State leadership can improve this situation. In many states, state community affairs agencies or others with similar functions may serve as a point of liaison for provision of planning or other assistance by state government to regional planning organizations as well as to counties and municipalities.

Summary

State government's leadership responsibility in a comprehensive state emergency management program is to see to it that the intergovernmental relations with subordinate jurisdictions are well established and understood by state and local agencies as well as by the private sector which works with and looks to these agencies. The time when disaster strikes is not a time when establishment of these understandings can be effectively accomplished.

The state's responsibility must go further, however, if hazard mitigation, response, and recovery efforts are to be effective and successful. The best arrangements for mitigation planning, disaster response, and recovery development must be determined and established, and needed standards and regulations for public protection must be adopted. In addition, adequate and continuing financial arrangements must be established in order to ensure that the objectives of such programs can be accomplished.

Public education and information programs conducted by the state are other examples of ways in which states can provide appropriate assistance on a statewide basis. Technical information and advice from many state agencies, particularly the state universities, can supply knowledge not otherwise available at local levels. In many instances federal financial and technical assistance is best arranged through state agencies, an arrangement very often preferred by federal agencies since they cannot deal with hundreds of local bodies.

LEGISLATIVE AUTHORITY AND LEGAL LIABILITY OF STATE AND LOCAL OFFICIALS

Model state disaster legislation developed by the Council's Committee on Suggested State Legislation in its 1972 program and revised in 1974 has been utilized, adapted, and adopted by legislatures in more than 35 states. Every state has legislation which in one way or another authorizes both state and local programs for natural hazard preparedness. Each state also has inherent sovereign police power, often delegated to local jurisdictions in varying ways, which has great relevance in the case of actions taken before or after disasters for promotion of public health, safety, and welfare.

States should take steps to assure that they have adequate legislative authority to meet present-day challenges and achieve effective comprehensive emergency management. This is advice consistent with recommendations of recent National Governors' Association studies and reports as well as with actions being taken by the federal government cited in Chapter 1. A sound legislative base is needed if a state is to fulfill its natural hazard responsibilities as outlined in this report.

Considerations of law and public policy, particularly those authorizing public programs and defining public responsibilities, never take place in a vacuum. A legislative body will always view such enactments in relation to the threats perceived and the measures believed necessary to cope with them. Costs, and where they are to fall, are always in the forefront of such legislative considerations, and these are not just the costs to government but also those affecting, directly and indirectly, communities and the people involved.

State legislative considerations are often dictated or heavily influenced by federal and local laws, policies, and customs. This is especially true with emergency preparedness matters, where a state legislature may be seeking to conform to a requirement established by federal law and, by so doing, may be establishing requirements to be met by its political subdivisions. Some of the difficult issues state legislators must deal with when considering emergency preparedness are how far the state should intrude into established local authority; whether the state should set minimum standards; the extent of financial aid and its sources; and whether, in what circumstances, and to what extent state command authority will supersede that of political subdivisions. The theme emphasized in this report is that responsibilities in emergency management are shared by federal, state, and local levels of government. This contributes to the complexities of related legislative considerations at all three levels.

One example of these considerations is found in the recently enacted Earthquake Hazards Reduction Act of 1977. This federal act assumes that earthquake warnings will be issued by the governor of a state. State government representatives testifying at congressional hearings leading to the passage of this law did not object to this assumption. The president's Earthquake Implementation Plan can be assumed to place the responsibility for earthquake warnings on the states, with technical assistance in a state's evaluation of

earthquake predictions provided, at least in part, by instrumentalities of the federal government.

In states which are exposed to seismic risk, illustrated in the case of the state with a seismic safety commission described earlier in this chapter, their chief executives face a new requirement. They must evaluate earthquake predictions and have adequate authority and procedures for issuance of warnings, accompanied by advice and instructions for maximizing public safety and welfare.

As pointed out previously, progress in the science of earthquake prediction is creating issues different from those presented by most other natural hazards. But this is only partly so. In the case of earthquake prediction, differences in the threat and in the time elements involved can create several different kinds of problems, and new authority and arrangements for handling earthquake predictions and warnings are desirable. However, some issues applicable to release of hazard precursor information for other hazards and to liability of public officials in release of such information and in taking hazard reduction measures are not entirely dissimilar from that required for earthquakes.

The study on which this report is based gave special attention to the liability issue. An advisory committee was established by the National Association of Attorneys General to participate in this study. It concluded that state legislatures should expressly immunize both state and local officials from liability for good-faith warnings issued as a consequence of an evaluated earthquake prediction (see Appendix D).

The issues which confront state executive and legislative branches do not stop with warnings of likely earthquake tremors; they also apply to other actions of public officials designed to reduce hazards and respond to hazardous events. The increasing incidence of courts holding state and local governments liable, through their officials, for acts where "proximate cause" seems extremely remote or where the links are several times removed, has generated some rather bizarre results. This presents such questions as: Should state and local officials be immunized for liability for good-faith actions taken as a consequence of a warning? Should liability be limited? Should alternate arrangements such as administrative claims procedures and liability limits be sought?

Accordingly, the chain set in motion spreads across all the mitigation, response, and recovery acts to be taken by state and local officials. The state must decide the extent to which it will establish minimum requirements in hazard reduction measures involving land use management, safety and building construction codes, and other hazard reduction actions, and the means of implementing these measures and meshing the requirements with associated hazard-mitigation measures.

Responses to warnings by state and local officials raise questions as to whether state actions should override local authority in certain matters (for example, ordering evacuation, establishing curfews, shut-down of dangerous storage and utility facilities which are part of lifeline systems, and curtailment of other activities). The extent to which federal, state, and local regulatory agencies

will be required to take these factors into account in their functions offers an additional or alternative mode of approach, but again the questions which vex the legislatures as to who pays and how must be faced. Court actions may also be involved in these decisions.

In the long-range recovery phase following natural hazard disasters, does the state authorize recovery programs prior to the event, does it provide incentives to rebuild, and does it seek to coordinate federal, financial and other assistance? Many states may not act upon recovery efforts until after a disaster, then seek specific solutions to situations presented. States should, however, examine their options and take those planned, long-range recovery actions determined feasible in advance of an event in order to accelerate realization of desirable recovery objectives.

State governments and the Council of State Governments have not gone so far as to develop suggested state legislation dealing with many of the issues described above. This may well be a next step warranting consideration by state officials.

PERSONNEL RESOURCES FOR PLANNING HAZARD REDUCTION PROGRAMS

This report, seeking to emphasize hazard mitigation as part of comprehensive state hazards programs, has repeatedly stressed the need for continuing, coordinated planning in order to reach that goal. The organizational alternatives presented did so, pointing out that coordination of hazard reduction planning performed in nonemergency situations can best be handled by those aides to a governor concerned with coordination of planning and policy development for regular state services.

Two advisory committees of state officials participated with the Council in the study which led to this report—state planners and state emergency services directors. Both committees recognized that state planners can play a key role in achieving hazard mitigation. State planners supported the concept that hazard mitigation is an objective of concern in comprehensive state planning. Emergency services officials recognized that the major tools of mitigation—growth policy, land use, economic policy, building regulation, and integration of planning at state, substate, and local levels of government—lie in areas which involve state planners. Neither group underestimated the important contribution which emergency services personnel could also make to hazard mitigation policies and programs.

There are obstacles to achieving the participation of state and local planners in hazard reduction initiatives. For one thing, the potential of their role has not been adequately recognized by many state and local chief executives, by some planners, and even less by many lay members of local city and county planning bodies.

But even if their role were clearly seen and fully appreciated, the lack of planning personnel experienced in and trained for analysis leading to hazards mitigation policy and program development could be a stumbling block. The

lack of such personnel resources may also turn out to be an impediment to the Federal Emergency Management Agency in its efforts to implement new federal policies in support of hazard mitigation.

Another potential obstacle, with implications extending to other aspects of state administration, is the lack in many states of effective merit system provisions to assure reasonable tenure for hazard mitigation planners. These planners are engaged in work where their value in dealing with such long-range problems is enhanced by skills, knowledge, and institutional memory acquired over a period of years. It is antithetic that state employees engaged in disaster programs who are paid partially or wholly from federal civil defense funds are assured tenure and merit system protection by federal requirements, whereas other state personnel in similar or related work may not have such protection.

These obstacles point to the need for steps to overcome them. The shortage of hazard mitigation planners should, in particular, be moved high on the list of problems to be solved.

Because this shortage is considered a nationwide problem, applicable to activities of federal, state, and local governments, national leadership hopefully will be provided by the Federal Emergency Management Agency. The National Science Foundation and the Office of Intergovernmental Personnel Programs of the new federal Office of Personnel Management can also be helpful. So can national associations of public officials and such organizations as the National Association of Schools of Public Affairs and Administration, the American Planning Association, and the National Training and Development Service.

Early steps, not unlike projects which have tackled similar problems in other fields of public endeavor, might include action aimed at (1) developing model graduate-level education programs for planners oriented to hazard mitigation, including formulation of suggested curricula and the identification and enlistment of schools around the country best equipped to offer such programs; and (2) training state and local planners and policy analysts now working in state government, regional planning agencies, and local jurisdictions in aspects of natural hazard mitigation and crisis management to which they have had little exposure. A few universities offer courses for urban and environmental planning and could, perhaps more readily than others, adapt programs to meet these needs. However, the complexities of hazard mitigation require persons knowledgeable in analyzing and dealing with issues of general public policy and affairs.

A cross-fertilization of various academic disciplines is particularly pertinent in the development of these education and training programs. Physical and social scientists have given attention to hazard reduction research, and a number of academic institutions as well as the Natural Hazards Research and Applications Information Center at the University of Colorado have sought to develop and encourage interdisciplinary approaches in natural hazards research. An increasing number of state and local public administrators have been among participants in recent natural hazards research workshops held at the University of Colorado. Only within the past few months has a first article on disaster

mitigation appeared in the *Public Administration Times*, a publication of the American Society for Public Administration.¹¹

Implementation of new federal policies in support of hazard mitigation as an effective deterrent to disaster losses can be expected to create a demand for trained environmental planners from various disciplines. State governments should be ready to join in constructive efforts to meet this need and should seek and support national leadership from federal agencies whose programs also call for planners oriented to the objectives of hazard mitigation.

Footnotes

1. This is the traditional disaster management role found in state governments and in this alternative is so located that its director reports to the governor, as prescribed in the Example Disaster Act developed in 1972 by the Council of State Governments. This differs from the organizational location found in many states which places the emergency services assignment under the state adjutant general, a location stemming from earlier emphasis placed on civil defense functions when such functions were authorized during World War II and following enactment of the Federal Civil Defense Act of 1950.

2. There is a precedent for such a title. The federal government's organization includes a dormant agency carrying the title, "Office for Emergency Management." That office was established by President Franklin D. Roosevelt primarily to provide a framework within which civilian World War II agencies would be established. It was part of the Executive Office of the President. The Office for Emergency Management was headed by the president, as was the Executive Office of the President. The position of Liaison Officer for Emergency Management, suggested for use by state government in this report, was established in the federal government to assist the president in administering the Office for Emergency Management without removing his direct authority over key wartime agencies.

3. Karl V. Steinbrugge, former and first chairman of the California Seismic Safety Commission, recently served as chairman of a working group on earthquake hazards reduction created by the federal government's Office of Science and Technology Policy. He observed that up to eight states might create a separate state seismic safety organization. In other states, for example, where hurricanes are considered a special danger, a separate state agency might be created to deal with that perceived threat. Texas' 16-member Coastal and Marine Council, chaired by a state senator from the Gulf Coast area, is a statutory body which supplements activities of the state's Division of Disaster Emergency Services by giving special attention to flooding, evacuation needs, and other aspects of hurricane preparedness—including measures applicable to hurricane-spawned and other tornadoes. There is little evidence that states which create special agencies for certain hazards give corresponding attention to mitigation measures for hazards other than those singled out for such attention.

4. The Council of State Governments, *National Conference on Earthquakes and Related Hazards* (Lexington, Ky.: 1978).

5. Statement of Ralph H. Turner, Professor of Sociology, University of California at Los Angeles and formerly Chairman, Panel on Public Policy Implications of Earthquake Prediction, National Academy of Sciences (April 20, 1977).

6. City of Los Angeles, *Consensus Report of the Task Force on Earthquake Prediction* (Los Angeles, Calif.: 1978).

7. William Spangle and Associates, Inc., *Research on Post-Earthquake Land Use Planning: Alaska, Santa Rose and San Fernando (Portola Valley, Calif.)*.

8. Peter H. Rossi, James D. Wright, Sonia R. Wright, and Eleanor Weber-Burdin, "Are There Long-Term Effects of American Natural Disasters?," *Mass Emergencies*, vol. 3 (1978).

9. Louis Brownlow, *Passion for Anonymity*, vol. 2 (Chicago, Ill.: University of Chicago Press, 1958), p. 241.

10. The Alquist Priolo Special Studies Zones Act, subsequently amended in 1974, 1975, and 1976 (December 1972).

11. Claire B. Rubin, "Disaster Mitigation: Challenge to Managers," *Public Administration Times* (January 1979).

5. A Concluding Observation on Sharing

A reiterated perception that federal, state, and local governments in the United States necessarily share responsibility for public policies and programs dealing with natural hazards is the basic note on which this report should be concluded. Sharing in a partnership arrangement must be continuously recognized as the guiding theme, both in defining this responsibility and in fulfilling it.

Because three levels of government and so many public agencies are involved in this arrangement, comprehensive emergency management may well call for as complex a matrix of intergovernmental relationships as can be found among any public services. In some instances, plans will be developed to meet different aspects of a single situation at all three levels of government and services will likewise be delivered by federal, state, and local agencies.

The shared, intergovernmental nature of these responsibilities calls for careful consideration of the way in which the sharing is financed and accomplished. Oversimplification should be avoided. With regard to policy determination and resource allocation aspects of the sharing, care should be exercised to recognize the ways in which each level of government has an impact on other levels and on the respective roles of policymakers and administrators at each level, and on how desired results are to be achieved.

Administrative planning at executive levels and oversight by appropriate legislative bodies, especially from the vantage point of Congress, can be helpful and should not be neglected.

While there is need for national leadership and an active federal role is considered essential, to the maximum extent possible decisions should be made and services should be delivered close to the people affected. As the interests of a greater number of people become involved and as decisionmakers must take into account state, regional, national, and even international concerns, decisions necessarily should be made higher in the intergovernmental hierarchy. But this should be done with desirable and appropriate consultation and participation, with due regard to how needed services are to be provided.

Special Section on Natural Hazards Common in the United States

Information in this section is adapted, to a large extent, from four recent publications on natural hazards:

- Gilbert F. White and J. Eugene Haas, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975).
- Office of Coastal Zone Management, U.S. Department of Commerce, *Natural Hazard Management in Coastal Areas* (Washington, D.C.: 1976).
- J. H. Wiggins Co., *Natural Hazards: A Building Loss Mitigation Assessment: Final Report* (Washington, D.C.: National Science Foundation, 1978).
- Ian Burton, Robert W. Kates, and Gilbert F. White, *The Environment as Hazard* (New York, N.Y.: Oxford University Press, 1978).

These sources list extensive references in their bibliographies and are recommended to governmental planners concerned with natural hazards.

This section also includes supplemental information collected from other sources.

The 14 hazards discussed here are, in their order of presentation: avalanche, coastal erosion, drought, earthquake, flood, hurricane, landslide, tornado, tsunami, unstable soil, volcano, windstorm, winter storm, and storm surge.

AVALANCHE

Characteristics

An avalanche is a moving mass of snow or ice accelerating as it flows down a steep mountainside until a general gradient is reached. Avalanches are common in mountainous terrain throughout temperate and arctic climates of the earth and may occur wherever snow is deposited on slopes steeper than about 20 degrees. Avalanches often run in the same paths year after year, but exceptional weather and man's intervention through such activities as timber removal or development undertakings may alter these patterns or produce new ones. An avalanche can trigger other natural hazards such as landslides, or in some remote circumstances destructive sea waves (tsunamis). An avalanche coupled with unwise land management could result in a variety of man-made disasters like pipeline or nuclear facility disruption. Avalanches are also frequently triggered by other natural hazards such as earthquakes.

Incidence

Areas of incidence in the United States are in the western continental states, including the south and southeastern regions of Alaska (see Map 1). Dangers of avalanches are increasing in the United States as avalanche-prone areas become more heavily populated. Based on a reporting network existing since 1971, such hazards occur in the United States more than 6,800 times a year, with a relatively low annual death loss of seven. Property losses are estimated at an average of \$500,000 a year. Elsewhere losses have been much greater with at least 40,000 deaths resulting from avalanches in the Alps from 1915-18. The largest death loss in this country from a single incident was 118 persons, occurring in the Cascade region of Washington in 1910.

Hazard Reduction Measures

- Mapping of avalanche zones as an aid to public and private land management.
- Land use constraints on public lands; also for sites undergoing construction activities.
- Prevention through terrain modification.
- Triggering small avalanches to forestall larger ones.
- Disclosure of hazard potential in real estate transactions.
- Warning systems.
- Relief and recovery readiness effective for ice and snow conditions.

Sources and References

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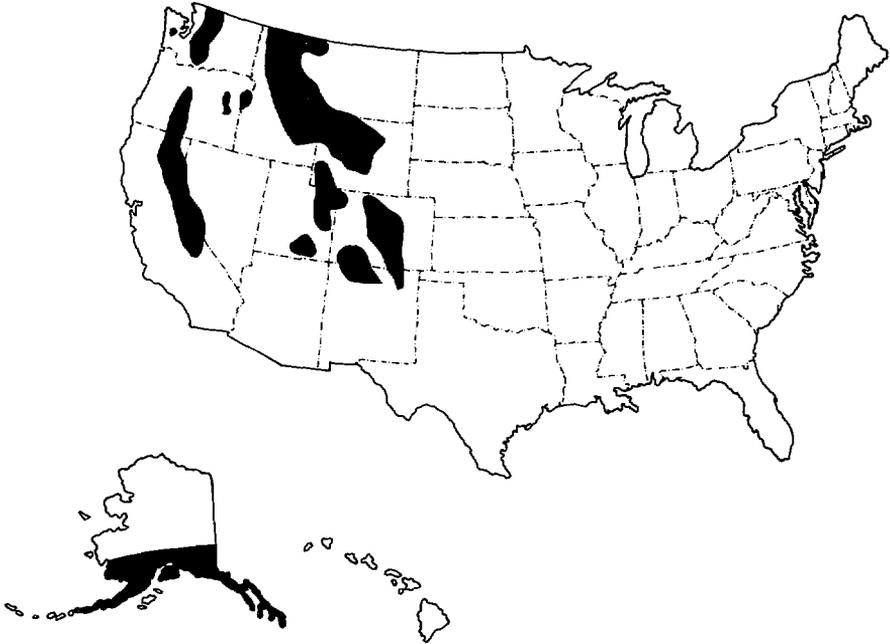
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Map 1
AREAS OF AVALANCHE HAZARD



Sources: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 349; and adapted from Office of Coastal Zone Management, U.S. Department of Commerce, *Natural Hazard Management in Coastal Areas* (Washington, D.C.: 1976), pp. II-68.

Data not available for Hawaii.

COASTAL EROSION

Characteristics

Coastal erosion is the set of processes by which more natural shore zone material is removed than deposited. This may be accomplished by water, wind, gravity, or biological action. Prime agents of erosion are waves and tides, but ice and drought can also act as agents. Man's actions along the coast, ranging from construction and sand mining to forced land subsidence through depletion of coastal groundwater and oil resources and removal of plant life, can exacerbate the natural erosion and frequently may cause it. The severity of this natural hazard can be greatly increased beyond a predictable norm at the time of a hurricane-induced or other storm surge. As the shore area of the nation becomes more intensely developed, there is an increased potential that coastal erosion will trigger man-made disasters as a result of actions such as improper siting of support facilities for offshore oil development.

Incidence

Current population concentrations and growth rates on the coasts of the United States make the natural hazard of coastal erosion a growing threat. Whereas an annual shoreline recession of 20 feet may pose no problem on an unpopulated beach, a recession rate of one foot or less may produce major damage and result in heavy financial loss on densely settled coasts. About one fourth or 20,500 miles of the national shoreline is subject to significant coastal erosion (see Map 2). Along 2,700 miles of that shoreline, coastal erosion is a critical problem. Significant erosion occurs where erosion processes and human activities conflict. Erosion is critical if it occurs where this conflict results in high investment loss and possible loss of life. Current losses from coastal erosion, primarily to private property and protective structures, amount to nearly \$300 million a year, probably a conservative figure.

Hazard Reduction Measures

- Coastal zoning to include land use controls.
- Shoreline permitting programs to protect critical areas.
- Building code restrictions.
- Public purchase of eroding shore lands.
- Structural installations, including stabilization by means of sea walls, etc.
- Land fill.

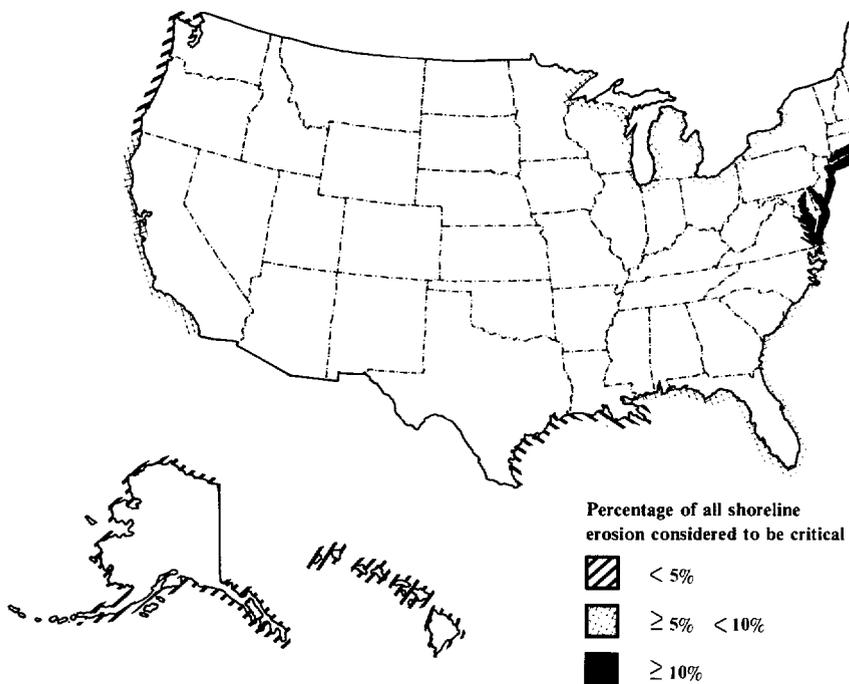
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Clark, John. *Coastal Ecosystems: Ecological Considerations for Management of the Coastal Zone*. Washington, D.C.: The Conservation Foundation, 1974.

Map 2
CRITICAL EROSION AREAS ON U.S. SHORELINES



Source: Adapted from map, "Severity of Shoreline Erosion" (Washington, D.C.: U.S. Corps of Engineers, 1971).

DROUGHT

Characteristics

Drought is one of the slowest-developing of the natural hazards. Agricultural production is the most obvious recipient of losses caused by this hazard. Given enough time, drought will also attack urban areas through domestic and industrial water shortages. A prolonged drought may result in severe national economic impact because of this country's dependency on income from exporting food and industrial products. Droughts are difficult to predict or forecast both as to when they may begin and how long they will last. Increased pumping of groundwater and surface irrigation occurring in drought periods can result in severe land subsidence problems.

Incidence

Almost all areas of the country are subject to direct impact from drought; vulnerability is shown in Map 3. All areas may be subject to indirect impact of drought as it affects their water supply systems. The most vulnerable regions are the arid southwest and the semiarid part of the midcontinent, particularly the Great Plains. During the last 100 years, major sustained droughts have occurred in these regions roughly once every 20 years. An estimated average annual production and crop loss in the Great Plains is \$700 million, but this is only part of the effect.

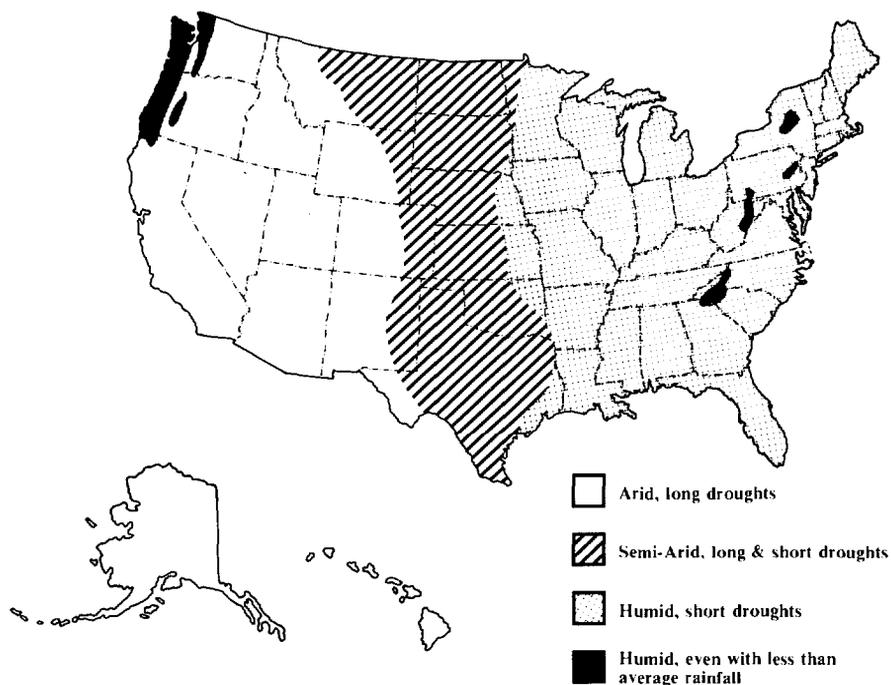
Hazard Reduction Measures

- Land use regulation especially applicable to drought-prone areas.
- Soil erosion controls.
- Improved agricultural cultivation practices.
- Regulated irrigation practices.
- Water supply protection and conservation.
- Improved drought prediction and forecasting.
- Stimulation of rainfall by weather modification (e.g., cloud seeding, etc.).
- Desalination of sea water.

Sources and References

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Map 3
AREAS INDICATING DROUGHT VULNERABILITY



Source: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 372.

Data not available for Alaska and Hawaii.

EARTHQUAKE

Characteristics

An earthquake combines a potential for great, sudden damage, both directly and through triggering other hazards. Characteristics of earthquakes are that they are relatively infrequent and of short duration, zones are relatively limited, the speed of impact is fast in a fairly concentrated area. Among natural hazards, earthquake tremors have a high potential for extreme severity, augmented by a wide range of very serious natural and man-made hazards. Of these, fire is a significant hazard. Other offspring include tsunamis, avalanches, landslides, and land subsidence. Floods often result due to failure of man-made structures. Other man-made disasters that can be triggered by an earthquake include contamination of land, air, water, and food through spillage and rupture, failure of structures and facilities due to poor construction standards, and destruction due to unwise management of land.

The increasing expectation that scientific efforts will produce an ability to predict earthquakes, possibly even substantially in advance of earthquake events, presents both difficulties and uncertainties, as well as opportunities for hazard reduction measures to mitigate damage. The former can have undesirable social and economic effects on individuals and communities, some of which can be allayed. The latter can lead to decisions or actions to protect people and facilities, though likely accompanied by uncertain cost-benefit indications.

Incidence

Seismic studies show that at least 39 states, in which approximately 70 million people live, are subject to major or moderate earthquake hazards (see Map 4). The recorded history of this nation shows that only 25 of the 50 states have been "virtually free" of direct or indirect impact from earthquakes. The potential losses from a major quake range to billions of dollars in damage and tens of thousands in fatalities. The nation's record of earthquake loss is one of good fortune rather than low seismic risk. To reduce the threat of earthquakes an accurate and timely prediction system is being sought. To have such a system, seismic zones must be better defined. This definition has been best done at continental-oceanic plate margins, such as along the Pacific coast. It is less clear within and along plate boundaries in the central and eastern part of the country, where much less is known about potential seismic hazards. In recent years, research of seismic risk areas within the central and eastern continental United States has been accelerated by the U.S. Geological Survey and others.

Hazard Reduction Measures

- Improved delineation of seismic risk areas.
- Earthquake resistant new construction.
- Steps to minimize damage to existing structures.
- Land use management.
- Earthquake insurance.
- Seismic risk disclosure in property transactions.
- Advanced earthquake prediction technology, accompanied by state evaluation of earthquake prediction.
- Reduction of associated hazards, with special attention to lifelines engineering and critical facilities.
- Differentiation between measures related to advance prediction and those applicable to disaster occurrences.

Sources and References

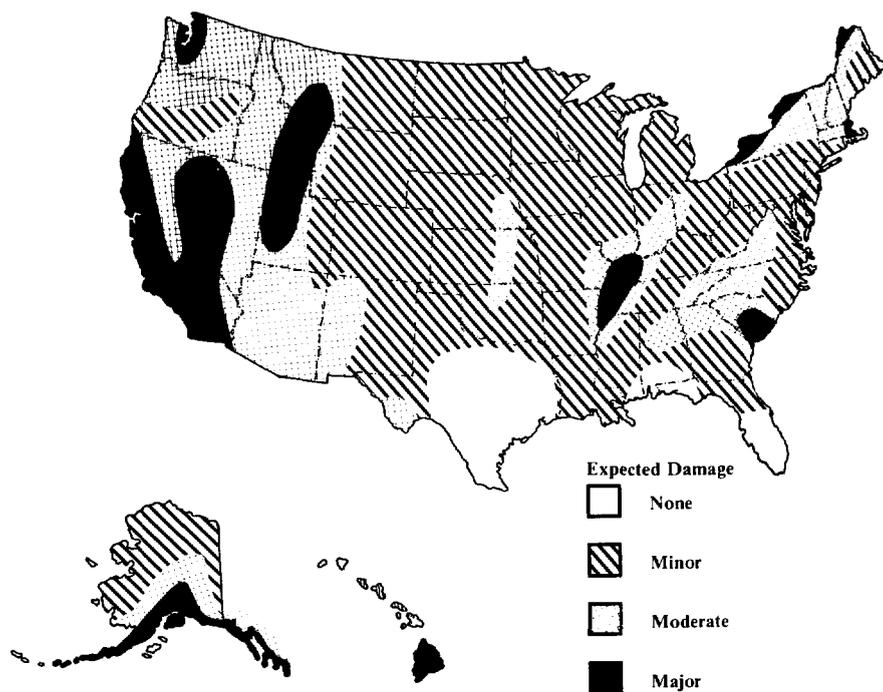
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Map 4
SEISMIC RISK AREAS



Source: National Science Foundation and U.S. Geological Survey, *Earthquake Prediction and Hazard Mitigation Options for USGS and NSF Programs* (Washington, D.C.: 1976) pp. 6-7 (attributed to Algermissen, 1969, and Uniform Building Code, 1973).

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FLOOD

Characteristics

Floods represent the most common and best known of the natural hazards. They also encompass the broadest range of characteristics among the natural hazards. Floods can occur quickly, as in flash floods, or slowly, as with those caused by spring thaws. They can be of extreme magnitudes in confined locations, such as canyons, or a costly nuisance, as in broad river valleys at planting time. Because many of man's major settlements are on or near water, they are exposed to this hazard. Many structural hazard reduction measures that are used against floods, such as dams and river channelization projects, have increased rather than decreased the disaster potential from this hazard. Floods are also a frequent "fellow traveler" with other hazards, such as snow, tornadoes, and hurricanes.

Incidence

All states have the potential to experience some degree of flooding and the resulting damage (see Map 5). Variations in the potential may be due to seasonal flooding or to severe and unusual weather patterns. Annual losses vary considerably from less than \$300 million in 1970 and 1971 to more than \$4 billion in 1972, when Hurricane Agnes floods devastated many parts of Pennsylvania and other North Atlantic states. By any estimate it is a very costly hazard. According to the National Oceanic and Atmospheric Administration, flash floods now rank as the major killers and destroyers among weather-related disasters in the United States. Since 1968, the average annual death toll from flash floods has risen to about 200, more than double the rate of the 1960s and more than triple the rate of the 1940s. Property damage in 1978 was running at about \$1 billion a year. The Federal Disaster Assistance Administration reports that about 85 percent of all presidential declarations of major disasters currently are associated with floods. The U.S. Water Resources Council predicts that damage from floods will reach \$3.5 billion annually by the year 2000 unless floodplain management is improved.

Hazard Reduction Measures

- Land use management, with special attention to floodplains.
- Federal flood insurance.
- Building construction and codes.
- Warning systems.
- Control and protective works (e.g., flood proofing, dams, reservoirs, levees, dikes, drainage systems, etc.).

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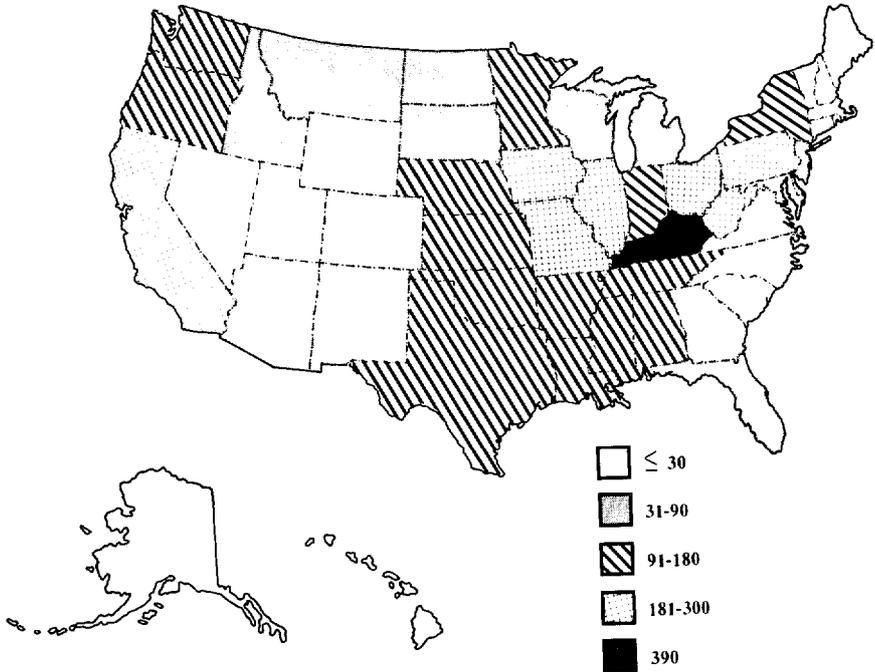
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Map 5
NUMBER OF FLOOD AND FLASH FLOOD EVENTS
1945-1976



Source: Adapted from map, "Flood and Flash Flood Events (Red Cross Reported) 1945-1976" (Washington, D.C.: National Weather Service, U.S. Department of Commerce, undated).

HURRICANE

Characteristics

Hurricanes are severe tropical cyclones with winds spiraling counterclockwise toward a low-pressure center known as the "eye." Wind speeds range from 74 miles per hour up to a high of 220 miles per hour in a narrow ring surrounding the eye. Picking up heat and moisture from the ocean, the potential for heavy winds and rain is developed, with a possible hurricane diameter of 300 miles as it crosses the coastline. At first traveling slowly, the speed of a hurricane picks up as it drifts northward. In a major hurricane, very high gusts of wind are experienced, perhaps 100 miles from its center. With the wind comes a storm surge, a rise of water above mean tide levels. Other natural hazards that frequently accompany hurricanes and cause severe damage are flooding of streams caused by heavy rainfall, accelerated coastal erosion, and severe storm systems. Disasters from man-made hazards may also occur depending on man's lack of foresight in the design of facilities exposed to such storms.

Incidence

This threat annually hangs over 21 eastern and southern coastal states for three to six months, from spring through fall (see Map 6). Loss of life has decreased in recent years, but property damage from hurricanes has rapidly mounted due to accelerated population increases and development in coastal areas. Average annual damage has risen from about \$250 million in the 1960s to \$400 million in the 1970s. The threat is more acute in those states where there is a high population of elderly people, increased use of mobile homes, and a high degree of urbanization accompanied by increased capital investment.

Hazard Reduction Measures

- Cloud seeding and other hurricane modification techniques.
- Building code regulation for hurricane-force winds and for reasonable wave force.
- Mobile home anchorage requirements.
- Evacuation routes and facilities.
- Use of national flood insurance, also of insurance available for wind hazards.
- Land use controls adapted to local conditions.
- Use of flood and wind-proofing technology, especially in public facilities.
- Possible use of well-constructed high-rise evacuation centers.
- Preparedness, response, relief, and rehabilitation measures, including effective warning capability.

Sources and References

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- Federal Disaster Assistance Administration. *A Public Official's and Citizen's Guide to Evaluating Local Hurricane Evacuation Plans*. Washington, D.C.: 1979.

Map 6
TRACKS OF DEVASTATING HURRICANES
1938-1973



Source: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 242.

LANDSLIDE

Characteristics

Landslides are characterized by a perceptible downslope movement of rock, debris or soil. Such movements are categorized as falls, slides, slumps, and earth flows. Frequently they accompany other natural hazards, particularly floods and earthquakes. Their relation to man-made hazards is limited only by man's intelligent management of land.

Incidence

Increased settlement activity by man on marginal lands and in coastal areas which are aesthetically desirable has resulted in increasing the threat from landslides. In 1970 all but eight states had an annual building loss of over \$1 million due to landslides—with 14 states having annual building losses in excess of \$10 million. Latest figures estimate direct and indirect losses from landslides to exceed \$1 billion annually. Areas of major severity include the west coast, the western front of the Rocky Mountains, the central Mississippi Valley, and the Appalachian region (see Map 7).

Hazard Reduction Measures

- Land use management.
- Application of geologic engineering knowledge and practice to prevent or correct landsliding.
- Strip mining regulation.

Sources and References

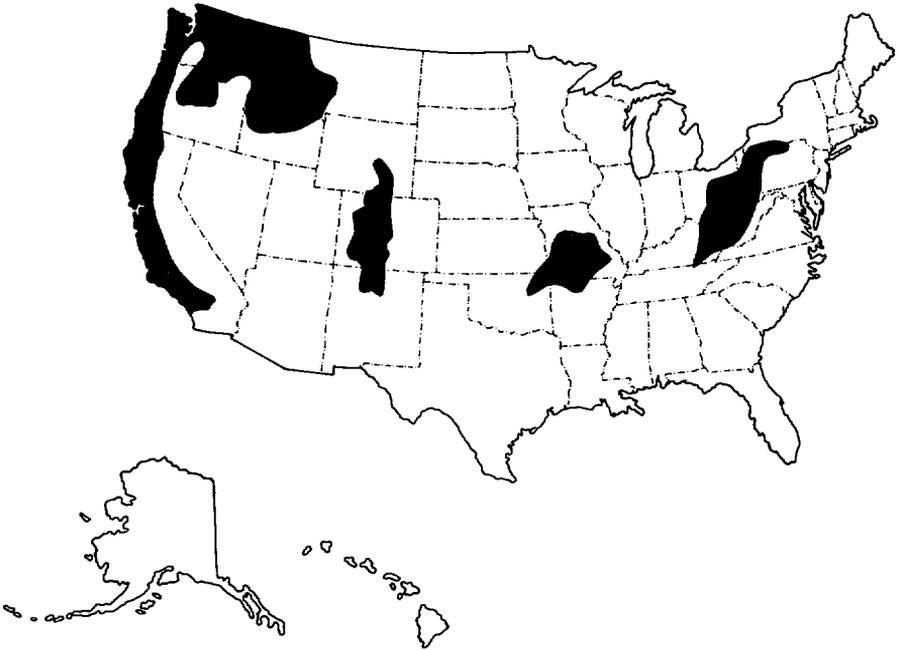
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Schuster, R. L. "Landslides Analysis and Control," *Transportation Research News*, No. 80 (January-February 1979).

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Schuster, R. L. and R. J. Krizck, eds. "Landslides—Analysis and Control," *National Research Council Transportation Research Board Special Report*, no. 176. Washington, D.C.: National Academy of Sciences, 1978.

Map 7
AREAS OF MAJOR LANDSLIDE SEVERITY



Source: Adapted from map, "Preliminary Landslide Overview Map of the Conterminous United States" (Washington, D.C.: U.S. Geological Survey, 1976).

Data not available for Alaska and Hawaii.

TORNADO

Characteristics

The tornado is characterized by a funnel cloud which reaches to the ground with wind velocities within the funnel as high as 175 to 200 miles per hour and an interior air pressure of 10 to 20 percent below that of the surrounding atmosphere. Its capacity for damage depends on the violence of its winds, the length and width of its path, and the pressure differential. The typical length of path is 16 miles, but tracks of 200 miles have been reported. They come in the form of a single twister and in families of numerous tornadoes which are part of a single major storm system. Tornadoes are the most violent of the four hazards that are part of the meteorological hazard, the thunderstorm. These are cloud masses that may be six or more miles across, eight miles high, and may contain up to 500,000 gallons of water and enormous amounts of energy. Other hazards in these storm systems are high winds, lightning, and hail. These hazards may trigger flooding, coastal erosion, landslides, and avalanches. Power and communications failures are common among the many man-made disasters that a thunderstorm and its allies can precipitate.

Incidence

Map 8 shows those areas in the United States subject to frequent, occasional, and very rare occurrence of tornadoes. This natural hazard has a reputation of death and destruction throughout the continental United States, but primarily in the states east of the Rocky Mountains. The states in the midwest and southern Great Plains are under the greatest threat from spring through fall, although tornadoes have occurred in all seasons. In 1978 some 788 twisters were reported. Damage assessment due to tornadoes is difficult to determine. During the 1960-70 decades, property damage from tornadoes was estimated at exceeding \$50 million in each of six years. From 1920 to 1973 it was the biggest killer of all natural hazards, with 9,000 deaths from tornadoes compared to 5,000 from floods and 4,000 from hurricanes. The tornado death rate has been declining, with 62 lives lost in 1978, compared with a 28-year mean death toll of 111 per year. With severe tornadoes hitting the Texas-Oklahoma "tornado alley" early in 1979, the current year destruction appears likely to exceed that of recent years, with damage in that area alone already exceeding hundreds of millions of dollars in property damage in addition to a large loss of lives.

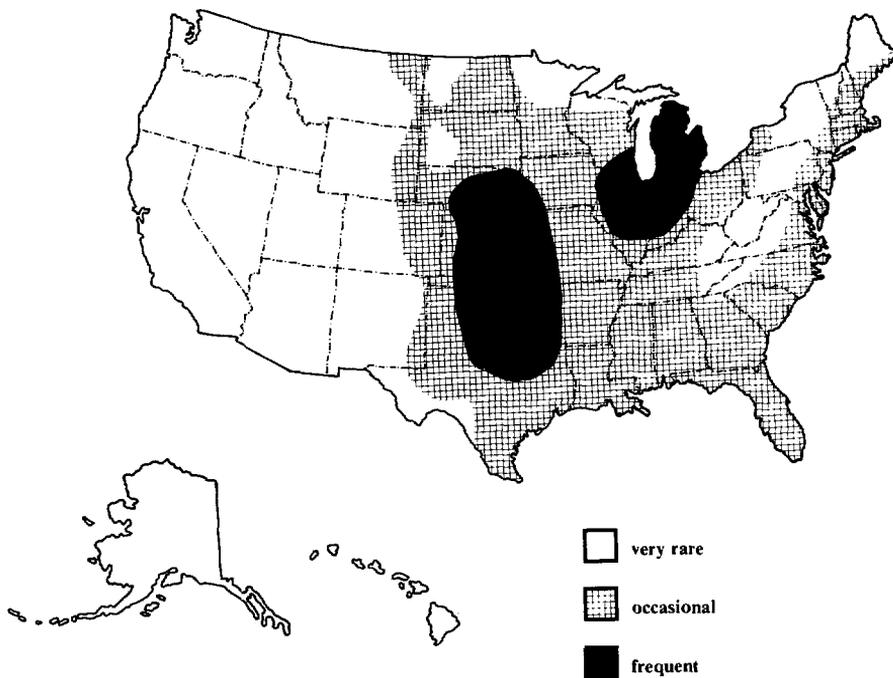
Hazard Reduction Measures

- Building codes, with provisions for high wind resistance, some of which may also apply to other hazards.
- Warning systems.
- In-house shelters.
- Insurance.

Sources and References

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Map 8
AREAS WITH TORNADO FREQUENCY



Source: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 274.

TSUNAMI

Characteristics

Tsunamis are most closely associated with earthquake activity, but they can also result from volcanic actions and other extreme movements of sediment into confined bodies of water, such as those caused by avalanches and landslides. They can be seismic-generated wave systems, classified as major, long-period waves that sweep out from an earthquake epicenter; also local, short-period waves in relatively confined bodies of water, locally generated. The most severe tsunami waves can move at speeds of hundreds of miles per hour in the open ocean and reach heights in excess of 100 feet when they finally break on shore. The results of such a tsunami can be described best by the word "devastating." They result in coastal erosion and flooding. They have the potential of triggering a variety of man-made disasters as do other coastal natural hazards.

Incidence

Tsunamis pose a recognized threat to the western coast of the United States from Alaska south and to the entire coastline of Hawaii (see Map 9). The potential for such seismic-caused activity exists for the eastern coast as well, but receives little attention primarily due to lack of recorded experience. The threat is probably greatest in bays and estuaries. Of course, the threat is heightened when man's settlements spread into such areas. Tsunamis following the great Alaska earthquake in 1964 resulted in 103 deaths and \$80 million in damages in Alaska.

Hazard Reduction Measures

- Warning systems.
- Evacuation of threatened areas.
- Tsunami prediction.
- Education programs.
- Limited structural and land use controls.

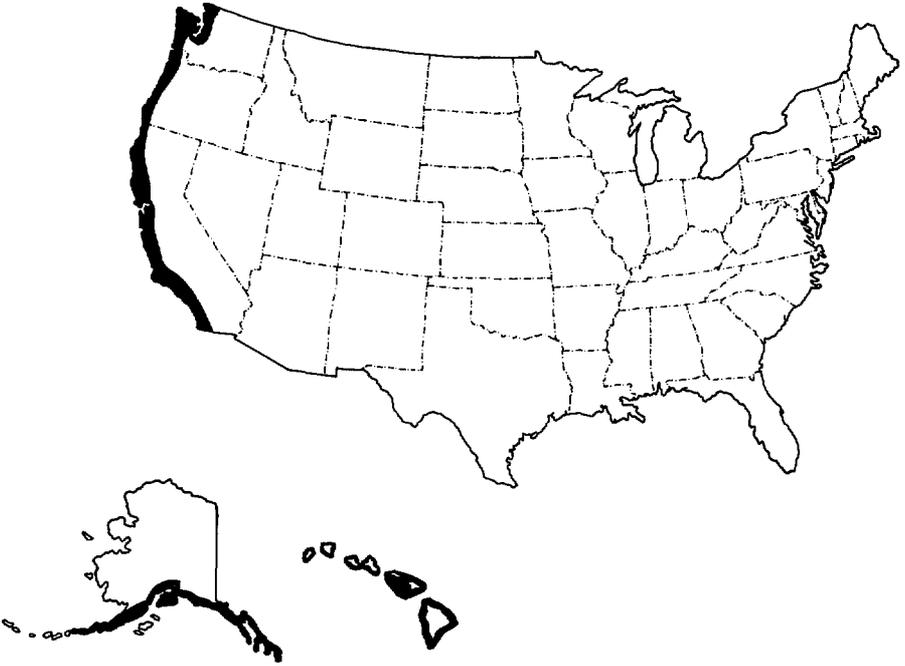
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Map 9
COASTAL AREAS HISTORICALLY SUBJECT
TO TSUNAMI



Source: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 320.

UNSTABLE SOIL

Characteristics

The term unstable soil as used in this report refers to the natural hazards both of expansive soils and land subsidence. Expansive soils are those types of soil, primarily montmorillonite, that when wetted absorb water and swell up to 15 times their dry volume rather than permitting the water to drain. These same soils then shrink when drying. Land subsidence is characterized by a falling ground level due to a relative increase in downward pressure, a decrease in the strength or volume of subsurface materials, or a combination of both. Both of these hazards can precipitate other hazards such as increased coastal erosion, flooding, and in extreme cases landslides and avalanches. Both can trigger man-made disasters related to the weakening and collapse of structures such as highways and pipelines. Finally, both may be caused as a result of man's activities such as altering normal water conditions or extracting resources from the earth.

Incidence

All states are threatened to some degree by these twin natural hazards that lurk in the soil. Expansive soils are most widespread in about 19 states (see Map 10). The probable area of occurrence for land subsidence is more difficult to establish because of the wide range of possible causes. A majority of these causes are either man-induced or triggered by other natural hazards, especially earthquakes and volcanos. As reported by studies of the J. H. Wiggins Co. (see Chapter 2), damage in terms of annual dollar loss to buildings due to expansive soil ties with that from hurricane and accompanying wind and storm surge for second place among America's most destructive natural hazards.

Hazard Reduction Measures

- Land use management.
- Building codes.
- Grading codes.
- Policy requiring pre-construction control of soil moisture, soil density, and site drainage control.
- Provision of soil analysis in real estate transactions.
- Injection of substitute fluids.

Sources and References

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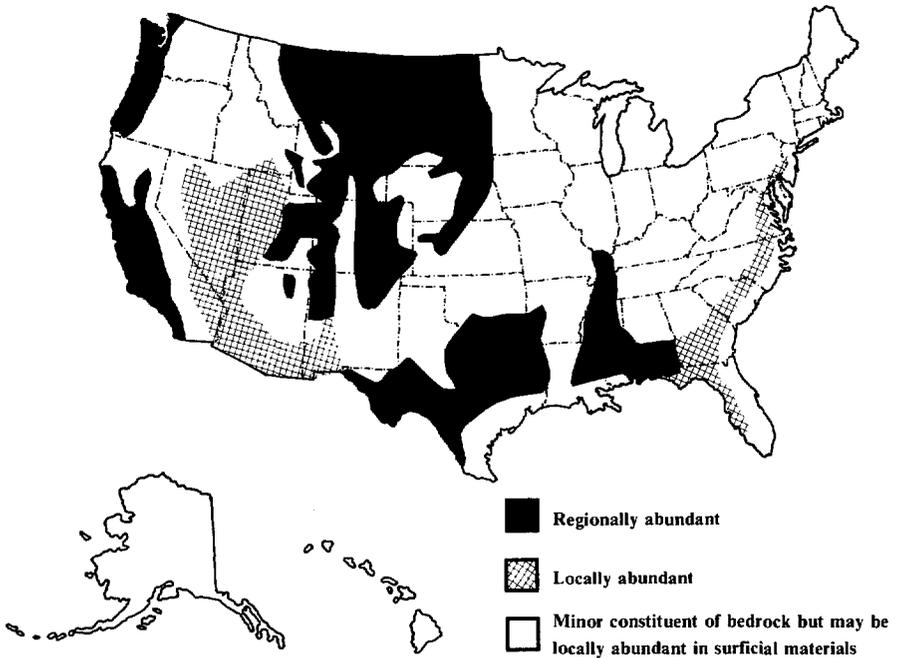
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Varnes, D. J. and G. Kiersch (eds.). *Reviews in Engineering Geology*, vol. 11. Boulder, Colo.: The Geological Society of America, 1969.

Map 10
AREAS CONTAINING EXPANSIVE SOILS



Source: Adapted from map, "Occurrence and Distribution of Potentially Expansive Materials in the United States" (Vicksburg, Miss.: U.S. Army Corps of Engineers Waterways Experiment Station, 1977).

Data not available for Alaska and Hawaii.

VOLCANO

Characteristics

A volcano is an eruption from the earth's interior of either the slower lava flow or the more violent pyroclastic explosion which issues rock, gases, and debris. The area covered by either of these eruptions can be limited to the geographic confines of the volcano or can range up to 100 miles on the ground and much farther in the atmosphere. The resulting mudflows can move with speeds from 20 to over 60 miles per hour. Volcanically generated natural hazards can include tsunamis, forest fires, debris avalanches, landslides, and land subsidence. The pyroclastic eruption is most prone to result in further disasters, such as contamination of water supplies.

Incidence

Three areas of the United States live with the threat of disasters that could be caused by volcanic activity. These areas are, in lessening order of frequency, Hawaii, Alaska, and the Cascade Range of the Pacific northwest (see Map 11). However, recent settlement patterns in the Pacific northwest present the greatest population-at-risk.

Hazard Reduction Measures

- Land use management.
- Possible lava flow controls.
- Prediction and warning systems.
- Evacuation routes.

Sources and References

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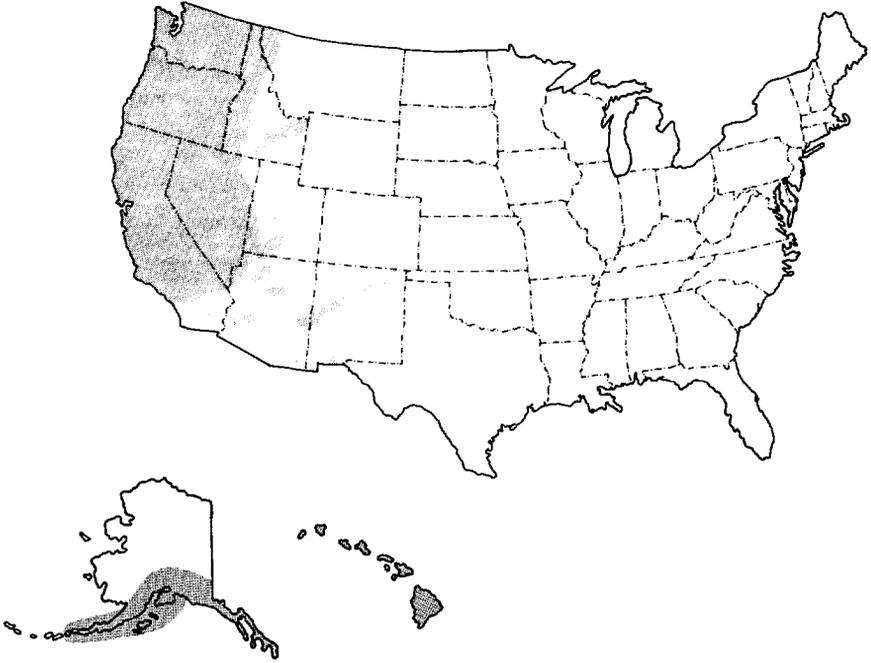
Hawaii Volcano Observatory, Hawaii Department of Land and Natural Resources, Hawaii Civil Defense Agency. Honolulu, Hawaii.

Tazieff, H. "The Menace of Extinct Volcanoes," *Impact* 17, no. 2 (1967).

Warrick, R. A. *Volcano Hazard in the United States: A Research Assessment*. Boulder, Colo.: Institute of Behavioral Science, University of Colorado, 1975.

Millineaux, D. R. "Preliminary Overview Map of Volcanic Hazards in the Coterminous United States," *Miscellaneous Field Studies*, MF-786. Reston, Virginia: U.S. Geological Survey, 1976.

Map 11
AREAS SUBJECT TO VOLCANIC HAZARDS



Sources: Adapted from map, "Preliminary Overview Map of Volcanic Hazards in the 48 Coterminous United States" (Washington, D.C.: U.S. Geological Survey, 1976); and Office of Coastal Zone Management, U.S. Department of Commerce *Natural Hazard Management in Coastal Areas* (Washington, D.C.: 1976), pp. II-65.

WINDSTORM

Characteristics

Windstorms in many cases develop from hazards previously discussed in this section, such as hurricanes and tornadoes. Additionally, there are down-slope windstorms in the mountains of southern California and on the eastern Rockies, and as a result of extra-tropical cyclones (the large-scale weather systems that march across the central United States to bring the familiar pattern of alternating fair and stormy weather). These winds range in speeds up to 100 miles per hour. The increased use of mobile homes and light-weight metal structures has increased the dangers posed by this natural hazard.

Incidence

Most areas of the continental United States, including Alaska, are subject to the threat of damage from winds with speeds in excess of 80 miles per hour. About 36 states suffer annual high wind damage, as shown in Map 12. In an average year, there are about 800 severe local windstorms. Average annual property losses over the past decade are estimated at \$30 million to \$300 million.

Hazard Reduction Measures

- Building codes.
- Mobile home tiedowns.
- Planting tree-shelter belts.

Sources and References

Thom, H. C. S. "New Distributions of Extreme Winds in the United States," *Journal of the Structural Division Proceedings of the American Society of Civil Engineers* 94 (1968).
National Weather Service, Silver Spring, Maryland.

Map 12
AREAS OF HIGH WINDS



Source: Adapted from Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), pp. 297-98.

WINTER STORM

Characteristics

This hazard includes snow and ice storms. The character of the hazards is determined by a variety of meteorological factors: snowfall, rainfall, temperature, and wind. In many areas this natural hazard can trigger extreme spring flooding. A high correlation exists between such storms and energy shortages, with a need that preparedness measures take both into account as they impact one another.

Incidence

Once blizzards and ice storms were viewed mainly as a threat to the livestock industry. Now, the apparent increasing fragility of urban settlements has made this natural hazard an annual threat to 60 million persons in the United States (see Maps 13 and 14). The severity of threat is dependent upon factors as varied as a community's level of preparedness for snow or ice storms and the urban area's size and industrial mix.

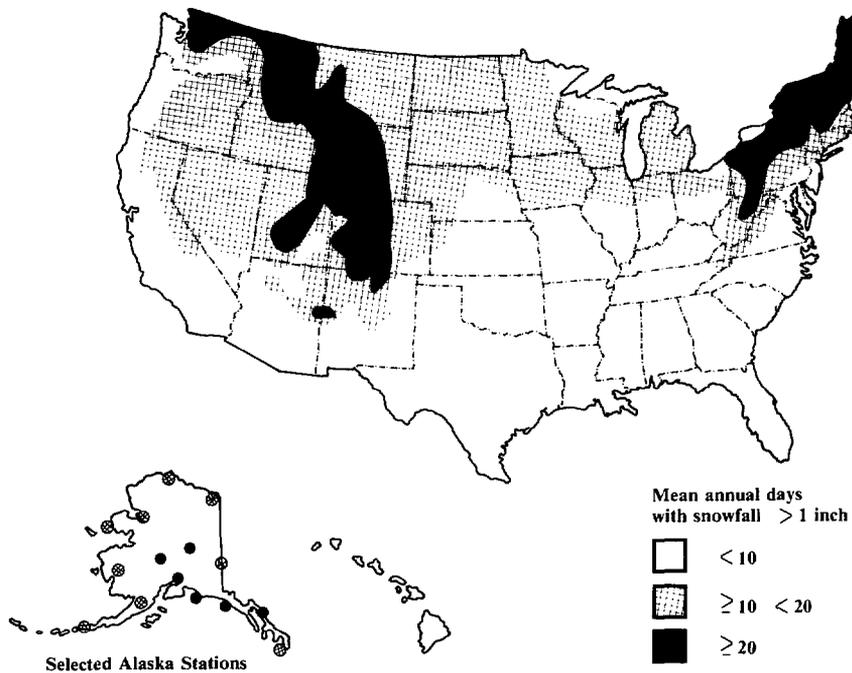
Hazard Reduction Measures

- Prediction and warning systems.
- Response plans especially adapted to such events.
- Flexible scheduling of public events and activities.
- Alternate energy supply systems.

Sources and References

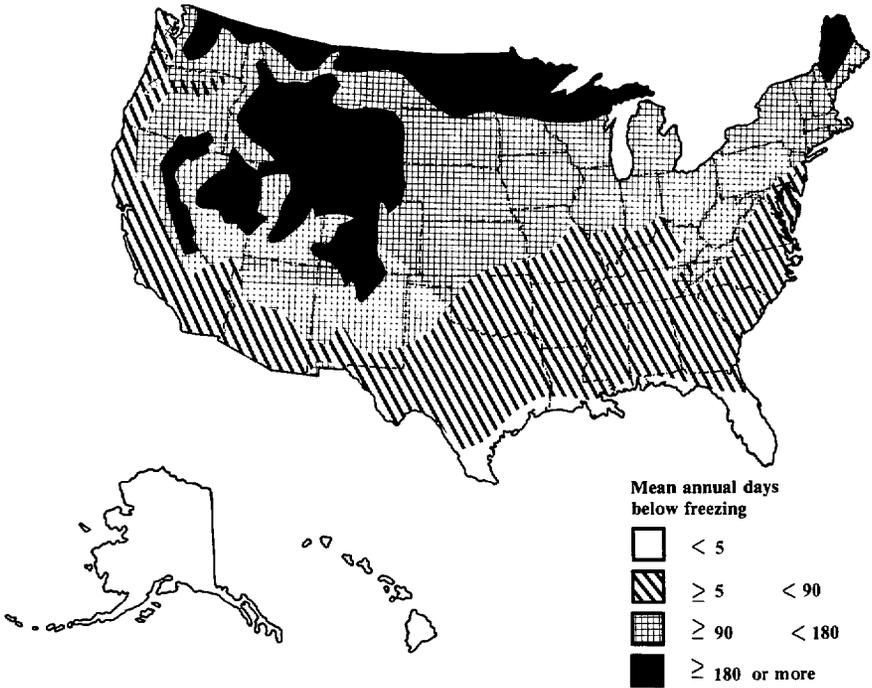
- American Public Works Association. Three national workshops in 1979. Chicago, Illinois.
- Rogers, W. J. and H. L. Swift. *Frost and the Prevention of Frost Damage*. Washington, D.C.: U.S. Government Printing Office, 1970.
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- National Weather Service, Silver Spring, Maryland.

Map 13
AREAS OF SNOWFALL



Source: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 312.

Map 14
AREAS AND PERIODS OF FREEZING



Source: Gilbert F. White and J. Eugene Hass, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 305.

Data not available for Alaska and Hawaii.

STORM SURGE

Characteristics

A storm surge is the influx of high water driven by a hurricane or other sea storms onto a coastal area. It accounts for almost 40 percent of all damage associated with hurricanes.

Incidence

Storm surge will occur wherever hurricanes do, as well as in other locations normally subject to damage by high tides. It strikes hardest in such low-lying coastal states as Florida, Louisiana, and Mississippi, but has also occasioned extensive damage in the Carolinas, Delaware, Maryland, Massachusetts, and other states. More than 6 million people are currently exposed to the storm surge hazard. About 40 percent of them live in zones where hurricanes may be expected with a return interval of one to 25 years, and more than one half of that population is located along the Gulf Coast.

Hazard Reduction Measures

- Special protection of structures and people against storm surge, especially as it returns to the sea.
- See also those listed for hurricanes.

Sources and References

Friedman, D. G. *The Storm Surge Along the Gulf and South Atlantic Coastlines*. Hartford, Conn.: The Travelers Insurance Company, 1971.

Nickerson, J. W. *Storm-Surge Forecasting*. Navy Weather Research Facility Technical Paper #10-71. Norfolk, Va.: 1971.

See also those listed for hurricanes.

Appendix A

ADVISORY COUNCIL AND SPECIAL COMMITTEES

Advisory Council

George L. Jones, State Coordinator, Virginia Office of Emergency and Energy Services
Richard Rubino, Associate Professor of Urban and Regional Planning, Florida State University
Keith F. Mulrooney, Executive Director, American Society for Public Administration
Donald Nichols, Chief, Earth Sciences Applications Programs, U.S. Geological Survey
Robert Olson, Executive Director, California Seismic Safety Commission
Gilbert F. White, Director, Natural Hazards Research and Applications Information Center,
Institute of Behavioral Science, University of Colorado

Special Committees of State Officials

National Association of Attorneys General

Slade Gorton, Attorney General, State of Washington, Chairman
Francis X. Bellotti, Attorney General, Commonwealth of Massachusetts
David C. Eckstrom, Alternate to Attorney General Daniel McLeod, State of South Carolina
Leland D. Ford, Assistant Attorney General, State of Utah
Geoffrey Graybill, Deputy Attorney General, State of California
John G. Proudfit, Assistant Attorney General in charge of the Environmental Protection
Bureau, State of New York
Louren R. Wood, Assistant Attorney General, State of Missouri

Council of State Planning Agencies

Robert D. Kuzelka, Nebraska, Chairman
Frank Beal, Illinois
John Halterman, Alaska
Rai Y. Okamoto, California (Director, San Francisco Department of City Planning)
Megan A. Takahashi, Utah
Henry G. Williams, New York
John Wilson, Tennessee

National Association of State Directors for Disaster Preparedness

Alex Cunningham, California, Chairman
Lee M. Epperson, Arkansas
Arnold W. Grushky, New York
James T. McClellan, Hawaii
Robert J. Gregory, Nevada
E. Erie Jones, Illinois
Betty McClelland, Washington

The Council of State Governments is also indebted to designated representatives from numerous federal agencies and professional and public interest groups, some of whom served on project liaison committees.

Appendix B

REPORT OF THE SPECIAL COMMITTEE ON EARTHQUAKE PREDICTION TECHNOLOGY AND PUBLIC POLICY CREATED IN COOPERATION WITH THE COUNCIL OF STATE PLANNING AGENCIES

Members of the committee met on two occasions—first, during the National Conference on Earthquakes and Related Hazards held by the Council of State Governments in Boulder, Colorado, November 16-18, 1977; second, on June 5 and 6, 1978 in Seattle, Washington, preceding the annual conference of the Council of State Planning Agencies.

The committee was in general agreement that state governments, primarily the governors, have a responsibility to take action—i.e., issue warnings—when an earthquake is predicted. Such predictions should be evaluated by the state in advance of issuing warnings, with such evaluation applicable to four components: time, place, magnitude, and probability.

Committee members, mostly representatives from agencies which primarily serve the chief executive officer—i.e., the governor—of a state, agreed that the governor had a prime responsibility for a wide variety of hazards. Such responsibility was recognized to include (1) that the governor should take a leadership role and, to the extent possible, prioritize mitigation measures for alleviating vulnerability to both natural and man-made hazards; (2) that such leadership role called for placing the coordination of hazard mitigation and recovery efforts close to the governor, either in his immediate staff or his policy planning office; (3) that, in the case of earthquakes, the governor was responsible for taking action at the time of a prediction, both to evaluate earthquake predictions and to issue warnings.

State planning representatives on the committee agreed that the following responsibilities were appropriate for assumption by state government:

- Assessing hazards and determining the most appropriate methods for limiting vulnerability via mitigation.
- Specifying inclusion of hazard-reduction elements in local land use or general plans.
- Establishing uniform building and safety standards to issue maximum protection in structures within the state against earthquakes and other hazards, with special attention to structures for critical public services such as power plants, dams, electrical transmission systems, energy pipelines, and other facilities of "lifelines systems."
- Seeking to bridge the gap between federal risk maps and data on natural hazards and the larger-scale maps and data required for application by state staff and by local planners and officials.

The group saw various possibilities for assigning natural hazard mitigation responsibilities, without agreement on any single way. For example, a state planning agency should have a role in mitigation, but there were differences in terms of its being a policy-setting, planning, or coordinating role. Because many other state agencies also have roles in hazard mitigation, the central role was seen by some principally as one of coordination; and the concept of a family of plans to deal with mitigation was also advanced.

The concept of a separate agency charged with comprehensive mitigation responsibilities was rejected, and different opinions supported roles for the state emergency response agency, the governor's policy staff, or a cabinet or subcabinet task force. Nor was there agreement on the state's role in enforcement of land use regulations and building codes.

Such differences of opinion focused attention on the great variety of implementing potentials and techniques appropriate for the 50 states.

Finally, members of the committee tended to agree on these aspects of the federal role in natural hazards reduction:

- The federal government should increase both financial and technical assistance to the states for natural hazard assessment and reduction activities.
- If earthquake warning risk insurance were to become a reality, federal assistance would be required.
- The federal government should devote a greater share of its disaster aid resources to be used in hazards mitigation.

An added suggestion was made that indirect costs might be funded by siphoning off funds from appropriate grants received by line agencies to state planning agencies for use in planning coordination activities.

It was reported that one state which has established a special agency for seismic safety programs also established a committee which held regular meetings looking at all hazards, including participants from the state seismic safety board, its emergency services agency, and the state planning agency, with the planning agency taking the initiative.

Report submitted by
Robert D. Kuzelka, Nebraska
Committee Chairman

NOTE: This report is based primarily on the committee's lengthier meeting in Seattle on June 5 and 6, 1978, at which all members of the committee were not present. Robert H. Wise, staff director, Council of State Planning Agencies, attended, as did representatives of the Council of State Governments. No formal resolution was prepared as in the case of the two other committees whose reports are included in this appendix, inasmuch as the Council of State Planning Agencies, unlike the two other organizations, does not propose or adopt resolutions.

Appendix C

REPORT OF THE SPECIAL COMMITTEE ON EARTHQUAKES OF THE NATIONAL ASSOCIATION OF STATE DIRECTORS FOR DISASTER PREPAREDNESS

The special committee, formed by this Association to assist the Council of State Governments in its examination of public policy issues arising from the increasing capabilities of scientists to predict earthquakes and in the development of proposals to deal with such issues, met on July 10 and 11, 1978, in the Chicago metropolitan area. An initial meeting was held in November 1977 at Boulder, Colorado, on the eve of the last day of the CSG-sponsored national conference at which many state emergency service organizations as well as other state offices were represented.

The committee considered a variety of public policy issues with regard to earthquakes and related hazards. Many of these arose in the context of the Earthquake Hazards Reduction Act of 1977 and the Implementation Plan developed by the Office of Science and Technology Policy and submitted to the Congress by the President on June 22, 1978, also in connection with Reorganization Plan No. 3 of 1978, for creation of the Federal Emergency Management Agency. The agenda of the committee's deliberations illustrates the scope of the inquiry, although the full nature of its considerations are not reflected by recommendations in this report. Issues raised by the agenda are, nevertheless, illustrative of some of the major concerns which members of the Association are likely to be faced with in coming months (or over longer time spans) in their capacity as public officials responsible for many aspects of disaster problems with which their states inevitably must deal.

The committee presents the following recommendations to the Association, and recommends their adoption by the Association:

Recommendation 1. The Earthquake Hazard Reduction Implementation Plan submitted by the President to the Congress (hereinafter, Implementation Plan) states: "Warnings and advice to people are primarily functions of state and local government. State governments may decide to set up their own advisory mechanism for evaluation of predictions." The committee believes it desirable that such a state mechanism, advisory to the governor and appropriately related to a National Earthquake Prediction Evaluation Council (expected to replace USGS's present evaluation council), be established to evaluate any earthquake prediction of concern in the state, thereby assisting in the governor's decision to issue or withhold a public warning. The deliberations of the proposed National Earthquake Prediction Evaluation Council established under the Implementation Plan can also assist the states, but it is recommended that a state evaluation by a formal or informal organizational arrangement, but using standardized procedures and seismic authorities who are knowledgeable about the area, be established according to each state's need.

Recommendation 2. Each state should review existing legislation to ascertain the adequacy of appropriate immunity from liability for the governor and other state or local officials engaged in evaluation of predictions and issuance of public warnings, and appropriate recommendations should be made to the legislature.

Recommendation 3. Each state should undertake an analysis of its statutes to ascertain the exposure of state or local officials to liability for actions taken or not taken upon issuance by the governor or local officials of an authorized public warning. Any statutory gaps or deficiencies should be presented to the legislature for its consideration and determination as to possible legislative action. Such consideration may also apply to the existence of precursor data known to be threatening but with respect to which a warning has not been issued.

Recommendation 4. While recognizing that seismic hazard reduction or disaster mitigation planning will be required, particularly affecting land use and construction regulation, state

governments, to the degree possible, should integrate such planning into a comprehensive emergency preparedness planning program. Mitigation as well as long-range recovery planning should preferably be coordinated for the governor by state planning or policy development offices, appropriately assisted by other state operating agencies and substate and local bodies. Response and immediate alleviation or recovery activities, as well as contributing to hazard reduction planning, are properly areas of concern for members of the Association.

Recommendation 5. The Implementation Plan states, "National maps on degree of seismic risk are needed to establish national priorities for earthquake hazard reduction activities; high priority will be given by the U.S. Geological Survey to the production of such seismic risk maps." Regional risk maps are also called for by the Implementation Plan. States must plan to (a) fill the gap from such regional maps to those more detailed ones required at substate and local levels, (b) determine the most appropriate methods for controlling vulnerability, and (c) establish priorities on measures to alleviate vulnerability. Substate and local governments may be the primary planning or action agencies, with maximum state assistance from community affairs and other appropriate agencies.

Recommendation 6. The Implementation Plan states: "State and local governments wishing to explore approaches to problems of existing hazardous buildings may obtain federal assistance through existing federal planning grant programs." Recent experience with federal planning grant funds to states and local governments indicates that funding is now inadequate and growing steadily smaller—not larger and more widely available. If state, substate, and local government efforts are to be effective, additional planning grant funds are needed for the development of hazard mitigation programs, in accord with recommendations supported by the Chairman of the Disaster Assistance Subcommittee of the National Governors' Association.

Recommendation 7. In almost all instances local governments cannot, by themselves, plan for or assure the safety of lifelines (water, waste disposal, energy and communications) in emergencies. States must plan for, and provide appropriate assistance, in full collaboration, as necessary, with the federal government. The federal government must assist states and their local jurisdictions in planning for restoration of lifelines, providing material assistance where necessary.

Recommendation 8. The federal government should take the lead in assuring the dissemination of hazard research results to state and local governments as well as other interested parties.

Attached to this report is a draft for the Association's consideration of a resolution which covers the major points of the committee's deliberations.

The Special Committee urges the Association's approval of the committee report, and its adoption of the draft resolution.

Respectfully submitted,
Alex Cunningham, California
Chairman of the Special Committee

**PROPOSED NASDDP ASSOCIATION RESOLUTION
ADOPTING THE REPORT OF THE
SPECIAL COMMITTEE ON EARTHQUAKES**

WHEREAS, the President has submitted Reorganization Plan No. 3 of 1978 to the Congress, which establishes the Federal Emergency Management Agency and consolidates the principal disaster assistance functions into the new agency; and

WHEREAS, the message transmitting Reorganization Plan No. 3 contemplates there is to be an increased emphasis on disaster prevention and mitigation measures; and

WHEREAS, the Earthquake Hazards Reduction Act of 1977 calls for increased federal-state-local interaction to reduce or mitigate hazards from potential severe earthquakes; and

WHEREAS, this Association has appointed a special committee to assist the Council of State Governments in examination of public policy issues facing states arising from the increasing capabilities of scientists to predict earthquakes;

NOW, THEREFORE, THE ASSOCIATION AT ITS ANNUAL MEETING ASSEMBLED AT BURLINGTON, VERMONT, ON AUGUST 27-30, 1978, ADOPTS THE FOLLOWING RESOLUTIONS:

RESOLVED, the report of the Association's special committee on earthquakes, and the recommendations therein, are adopted as those of the Association; and be it further

RESOLVED, inasmuch as the President's Earthquake Hazard Reduction Plan states: "Warnings and advice to people are primarily functions of state and local government. State governments may decide to set up their own advisory mechanism for evaluation of predictions," each state subject to seismic risk should establish a state prediction evaluation system, by a formal or informal organizational arrangement, using standardized procedures and seismic authorities who are knowledgeable about the area, according to each state's need; and be it further

RESOLVED, each state should review existing legislation to ascertain the adequacy of appropriate immunity from liability for the governor and other state and local officials engaged in evaluation of predictions and issuance of warnings, with appropriate recommendations being made to the legislature; and be it further

RESOLVED, each state should analyze its laws with respect to state or local officials' liability for actions taken or not taken upon issuance by the governor or local officials of an authorized public warning. Any statutory gaps or deficiencies should be presented to the legislature for its consideration and determination as to legislative action. Such consideration may also apply to the existence of precursor data known to be threatening but with respect to which a warning has not been issued; and be it further

RESOLVED, state governments, to the degree possible, should integrate seismic hazard reduction and mitigation into a comprehensive emergency preparedness planning program. Mitigation as well as long-range recovery planning preferably should be coordinated for the governor by state planning or policy development offices, appropriately assisted by other state operating agencies and substate and local bodies. Response, immediate alleviation and recovery activities, as well as contributing to hazard reduction planning, are properly areas of concern for state disaster directors; and be it further

RESOLVED, national and regional seismic risk maps to be issued by the U.S. Geological Survey will not be detailed enough for user agencies. States must plan to (a) fill the gap from regional maps to the more detailed ones needed at substate and local levels, (b) determine the most appropriate methods for controlling vulnerability, and (c) establish priorities on measures to alleviate vulnerability. Substate and local agencies may be the primary action agencies, with maximum state assistance required; and be it further

RESOLVED, recent state experience with existing federal planning grant funds to states (and to local agencies as well) is that they are inadequate and shrinking—not larger, and more widely available. If state, substate, and local mitigation efforts are to be effective, additional planning grant funds are needed for the development of hazard mitigation programs, in accord with

recommendations supported by the Chairman of the Disaster Assistance Subcommittee of the National Governors' Association; and be it further

RESOLVED, states must recognize local governments cannot, without assistance, plan for or assure safety of lifelines (water, waste disposal, energy, and communications) in emergencies. States must plan for and provide appropriate assistance, in collaboration with, as necessary, the federal government. The federal government must assist states and their local jurisdictions in planning for restoration of lifelines, providing material assistance where necessary; and be it further

RESOLVED, the federal government should take the lead in assuring the dissemination of disaster research results to state and local governments, and to other interested parties; and be it further

RESOLVED, that the Secretary of the Association is instructed to distribute copies of this resolution to those recipients designated by the President of the Association.

Done at Burlington, Vermont, this 30th day of August, 1978, at the 1978 annual meeting of the Association.

**NASDDP ASSOCIATION RESOLUTION
ACCEPTING THE REPORT OF THE SPECIAL COMMITTEE
ON EARTHQUAKES**

WHEREAS, the President has submitted Reorganization Plan No. 3 of 1978 to the Congress, which establishes the Federal Emergency Management Agency and consolidates the principal disaster assistance functions into the new agency; and

WHEREAS, the message transmitting Reorganization Plan No. 3 contemplates there is to be an increased emphasis on disaster prevention and mitigation measures; and

WHEREAS, the Earthquake Hazards Reduction Act of 1977 calls for increased federal-state-local interaction to reduce or mitigate hazards from potential severe earthquakes; and

WHEREAS, this Association has appointed a special committee to assist the Council of State Governments in examination of public policy issues facing states arising from the increasing capabilities of scientists to predict earthquakes;

NOW, THEREFORE, THE ASSOCIATION AT ITS ANNUAL MEETING ASSEMBLED AT BURLINGTON, VERMONT, ON AUGUST 27-31, 1978, ADOPTS THE FOLLOWING RESOLUTIONS:

RESOLVED, the report of the Association's special committee on earthquakes is accepted and the following recommendations are adopted as those of the Association; and be it further

RESOLVED, inasmuch as the President's Earthquake Hazards Reduction Plan states: "Warnings and advice to people are primarily functions of state and local government. State governments may decide to set up their own advisory mechanism for evaluation of predictions," each state subject to seismic risk should establish a state earthquake prediction evaluation system, by a formal or informal organizational arrangement, using standardized procedures and seismic authorities and authorize participation in multi-state or regional prediction systems, according to each state's need; and be it further

RESOLVED, each state should review existing legislation to ascertain the adequacy of appropriate immunity from liability for the governor and other state and local officials engaged in evaluation of earthquake predictions and issuance of, or failure to issue, official public warnings, and for immunity from liability for actions taken or not taken upon or in response to issuance by the governor or local officials of an authorized public warning. Any statutory gaps or deficiencies should be presented to the legislature for its consideration and determination as to legislative action; and be it further

RESOLVED, state governments, to the degree possible, should integrate seismic hazard reduction and mitigation into a comprehensive emergency preparedness planning program. State emergency preparedness and response planning should be coordinated with general planning processes, including those of substate and local bodies, in order to assure linkage with other state planning programs, especially those that contribute to the prevention and mitigation of hazards. Disaster response, immediate alleviation and recovery activities, as well as contributions to hazard reduction planning, are properly areas of concern for state disaster preparedness directors; and be it further

RESOLVED, national and regional seismic risk maps to be issued by the U.S. Geological Survey will not be detailed enough for user agencies. States should plan to (a) fill the gap from regional maps to the more detailed ones needed at substate and local levels, and (b) determine the most appropriate methods for controlling vulnerability; and be it further

RESOLVED, recent state experience with existing federal planning grant funds to states (and to local agencies as well) is that they are inadequate and shrinking—not larger, and more widely available. If state, substate, and local mitigation efforts are to be effective, additional planning grant funds are needed for the development of hazard mitigation programs, in accord with recommendations supported by the Chairman of the Disaster Assistance Subcommittee of the National Governors' Association; and be it further

RESOLVED, states must recognize local governments cannot, without assistance, plan for or assure safety of lifelines (water, waste disposal, energy, and communications) in emergencies. States

must plan for and provide appropriate assistance, in collaboration with, as necessary, the federal government, which must assist states and their local jurisdictions in planning for restoration of lifelines, and provide material assistance where necessary; and be it further

RESOLVED, the federal government should take the lead in assuring the dissemination of disaster research results to state and local governments, and to other interested parties.

Hayden Haynes
President

Attest: Oran K. Henderson, Secretary

Appendix D

REPORT OF THE SPECIAL COMMITTEE OF THE NATIONAL ASSOCIATION OF ATTORNEYS GENERAL ON EARTHQUAKE PREDICTION, WARNINGS AND PUBLIC POLICY

The Special Committee was formed during the term of the Honorable Slade Gorton as President of the Association. The Committee met upon three occasions—in November 1977 at Boulder, Colorado, in connection with a National Conference on Earthquakes and Related Hazards; on February 6, 1978, in Los Angeles; and on October 30, 1978, in Seattle. Attorneys General from the states of Washington, California, Massachusetts, Missouri, New York, South Carolina and Utah were represented on the Committee.

At least 22 states, according to the U.S. Geological Survey, Department of the Interior, are subject to some degree of earthquake hazard (42 FR 19292 et seq., April 12, 1977), although seismic studies show at least 39 states, in which 70 million people live, are subject to major or moderate earthquake risk. Committee representation sought a cross section of the degrees of risk to which the states are subject in this regard. Because of the groundbreaking activities of the state of California on measures intended to avoid or reduce hazards from earthquakes, the Committee, at its initial meeting, determined that it would utilize or adapt, to the degree practicable, steps taken by that state. Additionally, at the initial meeting of the Committee it was determined that consistent with the Earthquake Hazards Reduction Act of 1977, warnings of an earthquake, based upon an evaluated prediction, are properly a function of state government and that the warning itself should be issued by the governor. The Earthquake Hazards Reduction Act of 1977 expressly contemplates this will be done.

Accordingly, the Committee recommends that each state subject to seismic risk enact legislation to expressly immunize the governor, and other state and local officials, from liability for discretionary activities in connection with earthquake warnings, including activities involved in evaluation of predictions. The Committee also recommends that legislatures should consider immunizing doctors, nurses, and other medical personnel from liability based on medical treatment or care administered during an emergency caused by an earthquake.

The Committee's recommendation is based upon the several assumptions and reasons which are summarized below:

ASSUMPTIONS:

- 1) That the ultimate purpose of state involvement in earthquake prediction and warning is the mitigation of losses from earthquakes.
- 2) That the potential long-range savings resulting from an effective earthquake prediction and warning program are significant.
- 3) That state government decisionmakers are cognizant of and influenced by the costs associated with tort liability.

REASONS FOR IMMUNITY RECOMMENDATION:

- 1) Widespread uncertainty as to the extent of governmental liability places significant restraints on government involvement in activities, such as earthquake prediction evaluation and warning, where decisionmakers are unsure of their legal liabilities.
- 2) Because state earthquake prediction evaluation and warning programs are new and because the science of earthquake prediction is in its infancy, existing legal uncertainties must be resolved if earthquake prediction and warning programs are to develop their promise of significant loss mitigation.
- 3) Sovereign immunity from liability and its attendant certainty in laws relating to earthquake prediction and warning are essential to the development and use of that science.

4) The range of policy concerns which will be impacted by a state's liability are so diverse that they will be better addressed directly than by the uncertain and possibly random consequences of any statement of partial or total liability.

5) The potential savings in loss of life and property justifies the removal of disincentives to state government involvement in earthquake prediction and warning. As the science of prediction improves, states may wish to reassess the wisdom of a claim of total sovereign immunity.

COMMENTS:

In assessing the recommendation of the Committee, states are urged to consider the analytical framework upon which the recommendation is based. That analytical framework involves the consideration of seven possible approaches to state liability in view of eight broad policy considerations which are likely to be concerns of all state governments. Appended to this report is a paper by James Huffman who has served as a consultant to this Committee. The paper details the rationale of the analytical framework and suggests how that framework can be applied in practice. The table following his report summarizes these approaches and policy concerns, and suggests some of the factors which states will want to consider.

Most of the analytical elements apply also to the further question of immunity from liability for state or local officials for good faith actions, or failure to take action based upon warnings issued as a result of evaluated predictions. State legislatures considering the tort liability of state and local officials for such actions should find it a useful tool in their considerations of possible revision to tort claim statutes.

The Committee was assisted in its considerations by the participation in its meetings by the emergency services directors of the states of California and Washington, and by representatives of the Association of (San Francisco) Bay Area Governments, which was conducting a study of potential tort liability impact on decisions of local governments in earthquake situations. This participation showed that earthquake mitigation measures cannot be undertaken in isolation but must be integrated into an all-hazard approach, and that economic impact and where cost burdens fall will always be major considerations.

A severe earthquake in a densely populated area is potentially the greatest natural hazard the states face in terms of property damage and threats to life or severe bodily harm. The ideal long-range solutions to the threat of earthquakes are design, construction, and safety requirements and land-use management, which avoids creation of or mitigates the hazard. The Committee recommends that states at seismic risk consider legislation providing effective tools for avoiding or minimizing harm from earthquakes within cost-effective ranges.

As a part of this report, there is a proposed draft resolution, attached for the consideration of the Association, which would adopt the recommendations in the report as those of the Association. There is also attached a paper and chart on the ranges of options available, and the considerations involved, for those state legislatures which may wish to take action on the subject. This material provides some guidelines to assist in their deliberations.

Respectfully submitted,

Special Committee of the National Association
of Attorneys General on Earthquake Prediction,
Warnings and Public Policy

By: Slade Gorton, Chairman
Attorney General, State of Washington

**ADOPTED RESOLUTION OF THE
NATIONAL ASSOCIATION OF ATTORNEYS GENERAL ON
EARTHQUAKE PREDICTION, WARNINGS AND PUBLIC POLICY**

RESOLUTION accepting the report of the Special Committee on Earthquake Prediction, Warnings and Public Policy.

WHEREAS, Reorganization Plan No. 3 of 1978, submitted by the President to the Congress, which established the Federal Emergency Management Agency as a means of consolidating the principal federal disaster assistance functions into the new agency (FEMA), has taken effect; and

WHEREAS, the President's message transmitting Reorganization Plan No. 3 contemplates there is to be an increased emphasis on the part of the federal government on disaster prevention and mitigation measures; and

WHEREAS, the Earthquake Hazards Reduction Act of 1977 calls for increased federal-state-local interaction to reduce or mitigate hazards from potentially severe earthquakes; and

WHEREAS, the Earthquake Hazards Reduction Act of 1977 contemplates that earthquake warnings will be issued by the state, and the President's Implementation Plan submitted to the Congress pursuant to the provisions of the Earthquake Hazards Reduction Act of 1977 specifies that the states will perform the earthquake warning function; and

WHEREAS, this Association established a Special Committee on Earthquake Prediction, Warnings and Public Policy to assist the Council of State Governments in its study of the questions thereon;

NOW, THEREFORE, THE ASSOCIATION AT ITS ANNUAL MEETING ASSEMBLED AT ASPEN, COLORADO, ON JUNE 17-20, 1979, ADOPTS THE FOLLOWING RESOLUTIONS:

RESOLVED, the report of the Association's Special Committee on Earthquake Prediction, Warnings and Public Policy is accepted and the following recommendations are adopted as those of the Association; and be it further

RESOLVED, inasmuch as the federal government has placed the responsibility for earthquake warnings upon the states and their governing officials, that each state legislature immunize the state, its political subdivisions, and their officials, employees, and agents from liability for damage resulting from discretionary acts connected with earthquake predictions or warnings issued by them; and be it further

RESOLVED, that state legislatures evaluate the question of whether state and local officials should be immunized for their own good-faith mitigatory actions taken in response to a prediction or warning issued by the governor, such evaluation by the legislature to be assisted by the considerations included in the attachment to this resolution prepared for and adopted by the Special Committee; and be it further

RESOLVED, that land use management and construction and safety code requirements constitute the most productive method of approach to reduce earthquake-related hazards and preserve or protect lives and property in communities subject to seismic risk. Accordingly, state legislatures should consider the extent to which revised or new state codes should be adopted for the elimination, reduction, or mitigation of earthquake-related hazards; and be it further

RESOLVED, that the Association extends its appreciation to the Council of State Governments for the support provided the Special Committee in its consideration of the subject matter.

CONSULTANT'S REPORT: ANALYTICAL FRAMEWORK FOR LIABILITY ASSIGNMENT IN EARTHQUAKE ISSUES

The memorandum and chart which follow were prepared by Professor James L. Huffman, Director, Natural Resources Law Institute, Lewis and Clark Law School, at the direction of the Special Committee on Earthquake Prediction, Warnings and Public Policy of the National Association of Attorneys General. Professor Huffman served as a consultant to the committee.

The analysis is addressed to the issue of the state's liability for activities (or lack of them) arising from state involvement in earthquake prediction, including its evaluation. The analysis applies with equal force to public warnings of earthquakes issued by the state, with instructions by the state of actions to be taken by the public.

The chart depicting the range of options available to a state relating to assignment of liability for actions taken or not taken as a result of a public warning will also prove to be a useful tool for legislative consideration in this area.

The Special Committee was unanimous in its recommendation that state and local officials be immunized from liability for their actions in connection with earthquake prediction evaluation and warning. Council staff believes the material will prove its value in legislative considerations on this subject.

* * *

Several factors enter into a consideration of the appropriate state posture with respect to liability for state earthquake prediction activities.

Among these factors are the impact of the liability assignment on the social justifiability of state involvement in earthquake prediction, the nature of government behavior in response to alternative liability assignments, and the impact of those alternative liability assignments on the state's policy objectives. Those factors are discussed in the following paragraphs.

Central to a state's decision to become involved in any way with earthquake prediction must be the determination that the welfare of the state's citizens will be improved by the state's involvement.¹ The following analysis of the state liability issue assumes that the state's earthquake prediction involvement will lead to a net gain in social welfare. It is important to bear in mind, however, that the costs associated with the state of private liability are costs which must be incorporated into the general cost-benefit analysis of earthquake prediction. Because some rules of liability are more efficient than others, that is, they produce a particular social gain at less cost, the justifiability of state involvement in earthquake prediction will be impacted by the liability system in existence.

A simple example will illustrate the possible effect of liability assignment. Assume that a state determines that the issuance of an accurate earthquake prediction which leads to the evacuation of a high-risk area will result in avoiding \$150 million in losses at a cost of \$100 million, of which \$90 million results from the economic dislocation of the evacuation. Further, assume that the prediction is 50 percent accurate so that for every earthquake which occurs, there will have been two predicted earthquakes resulting in the mitigation of \$150 million in losses at a total social cost of \$200 million. If the state is liable for the injuries resulting from an inaccurate prediction, the state will pay the full \$100 million in costs resulting from the inaccurate prediction. Although the private parties will suffer the \$90 million in economic dislocation costs from the accurate prediction, they avoid \$150 million in costs which they would have suffered if there had been no earthquake prediction. Thus, there is no risk to private parties who comply with the evacuation. Either they avoid \$150 million in loss at a cost of \$90 million or they are compensated for the \$90 million if no earthquake occurs. The society as a whole, however, has avoided \$150 million in earthquake costs at an expense of \$200 million.

If liability for the economic dislocation costs of an inaccurate prediction rests with private individuals, they might seek to mitigate or eliminate those costs by permanent relocation or building modification. Although there would be costs associated with such relocation or structure reinforcement, they would occur only once, unlike the dislocation costs associated with evacuation. Whether or not it would actually be more efficient to relocate or suffer periodic dislocation costs would depend upon many factors, but they are factors which would be recognized in a situation of private liability and may not be recognized when the state is liable.

The preceding example suggests the second general factor of concern in assigning liability for harm resulting from state earthquake prediction activities—how government will act in the face of alternative liability arrangements. Traditional liability theory is based upon an individualistic model in which individuals respond to liability rules in accordance with their self-interest. The objective of tort law is to minimize the costs which result from one person's behavior impacting upon another person's welfare. The standard rule for liability assignment, given their objective, was expressed by Judge Learned Hand in the case of *United States v. Carroll Towing Co.*² Hand argued that a defendant should be guilty of negligence if the loss caused by the accident, discounted by the likelihood of the accident's occurrence, is greater than the burden of the precautions that the defendant would have had to take to avert the accident. In other words, we should not find a defendant liable if his avoidance costs exceed the costs avoided.

Harold Demsetz has demonstrated that the assignment of liability will make no difference in terms of resource allocation.³ But this is not always true unless it is assumed that transactions are costless. Transactions are not costless, of course, and the implications of transaction costs are important in the assignment of liability. In the words of Richard Posner, "Transaction costs are minimized when the law . . . places liability on the party who, if he had the right and transaction costs were zero, would sell it to the other party."⁴ In terms of the assignment of liability for earthquake prediction-related harm, this consideration is particularly important since many parties will be impacted and transaction costs will accordingly be high.

But the usefulness of this traditional liability theory in the assignment of liability to government is dependent upon the extent to which government behavior in response to rules of liability is similar to individual behavior. Because the "self-interest" of government is not easily defined or determined, it is not certain that government will act to optimize the welfare of the people it serves. Given this uncertainty, we must either develop a new liability theory having application to government behavior, or we must seek to guide government behavior so that it conforms to the individual behavior pattern upon which traditional liability theory is based. Since we do not have empirical data on government response to liability assignments, we are not in a position to develop a new liability theory. Hence, the remainder of this analysis is based upon the assumption that government behavior does or can be made to conform to the individualistic behavior upon which the liability theory articulated above is based. It is very important to be aware of the possibility that government does not fit the assumptions of traditional liability theory.

The table presented with this report outlines the relationship between alternatives for liability assignment and various policy concerns of the states. The liability alternatives range from a claim of total sovereign immunity to an affirmative declaration of state liability and includes three mechanisms for state compensation independent of the operation of the judiciary. Although the seven options identified appear to be independent alternatives, they may in fact be quite interdependent. Many direct state compensation systems do not prevent the receipt of judicially granted relief. Hence, no alternative should be viewed as exclusive of all others.

The policy concerns which are identified along the left hand side of the table are equally interrelated. For example, the magnitude of private transaction costs will clearly have a direct impact on the private decision to seek judicial or administrative relief and thus on the magnitude of private losses and of state liability. The magnitude of state liability will directly influence the willingness of the state to undertake earthquake hazard mitigation through issuance of an evaluated prediction. A careful examination of the table will reveal many of these interrelationships, but the complexity cannot be adequately demonstrated in a simple table. However, the table does define the main issues which should concern a state legislature which is contemplating action to alter or define liability for harm resulting from state earthquake prediction activities.

Footnotes

1. This objective would also exist if the state was involved in regulating private earthquake prediction.

2. 159 F.2d 169 (2nd Cir. 1947).

3. H. Demsetz, "When Does the Rule of Liability Matter," *J. Leg. Studies* 13 (1972).

4. R. Posner, *Economic Analysis of Law* 17, First Edition (1972).

THE POLICY IMPLICATIONS OF ALTERNATIVE STATE ACTIONS WITH RESPECT

LEGISLATIVE PROVISION FOR JUDICIAL RELIEF

<i>Problems which legislative action should address</i>	<i>Alternatives for legislative action</i>	<i>Claim of total sovereign immunity</i>	<i>Selective waiver of sovereign immunity</i>	<i>General waiver of sovereign immunity</i>
MAGNITUDE OF STATE LIABILITY		Assuming the validity of the doctrine of sovereign immunity, the state's liability would be zero.	The magnitude of state liability would depend upon the nature of the waiver (for what acts is liability assumed?), and the judicial application of common law doctrines (causation, negligence, etc.) to the state action for which relief is sought. The state cost is potentially high.	The magnitude of state liability would depend upon the judicial application of common law doctrines (causation, negligence, etc.) to the state action for which relief is sought. The state cost is potentially high.
MAGNITUDE OF PRIVATE LOSSES		Assuming the validity of the doctrine of sovereign immunity, private losses will fall upon those injured or upon those participating in insuring against such losses.	The magnitude of private loss will depend upon the nature of the waiver (for what losses is the state liable?), and the judicial application of common law doctrines (causation, negligence, etc.) to the state action for which relief is sought. Private loss is potentially low or even negative if collateral source recovery is not prohibited.	The magnitude of the loss will depend upon the judicial application of common law doctrines (causation, negligence, etc.) to the state action for which relief is sought. Private loss is potentially low or even negative if collateral source recovery is not prohibited.
MAGNITUDE OF GOVERNMENT TRANSACTION COSTS		Litigation and administrative costs will be minimal or non-existent. Some litigation of the validity of the immunity claim may be expected.	Administrative costs will be limited to administration of judicially awarded relief. Litigation costs will result from private suits and will be magnified by need to define scope of waiver. Those costs are potentially high.	Administrative costs will be limited to administration of judicially awarded relief. Litigation will result from private suits and will be potentially high.
MAGNITUDE OF PRIVATE TRANSACTION COSTS		Private costs resulting from transactions with government will be minimal, except for those challenging the immunity claim.	Private litigation costs will be high because of the need to demonstrate injury resulting from state action for which immunity has been waived.	Private litigation costs will be high, although the absence of the issue of the extent of the waiver of immunity will simplify litigation.
IMPACT OF LEGISLATIVE ACTION ON STATE CONDUCT		State earthquake prediction activities will be unrestrained because of no prospect of liability for harm resulting from those activities.	Depending upon the nature of the immunity waiver, state earthquake prediction activities may be restrained by the prospect of liability for some activities and unrestrained by the prospect of immunity for other activities.	State earthquake prediction activities may be restrained by the prospect of liability for harm resulting from those activities. The extent of the restraint will depend upon judicial determinations of causation and negligence and upon the magnitude of damages awarded.
IMPACT OF LEGISLATIVE ACTION ON PRIVATE CONDUCT		Private individuals will have total certainty that they will bear losses associated with state earthquake prediction activities. They will therefore take private action to minimize those losses.	Depending upon the clarity of the statutory waiver and the availability of judicial interpretation, private individuals will have varying degrees of certainty about where the costs will fall. With increasing uncertainty, there will be increasing disincentives to undertake private actions which might be negatively impacted.	There will be a degree of uncertainty about who bears earthquake prediction related losses resulting from possible variation in level of damages awarded. If damages are high, private individuals may have incentives to engage in activity in which they would not engage if they had to bear the losses.
IMPACT OF LEGISLATIVE ACTION ON CONDUCT OF OTHER GOVERNMENTS		To the extent that other governments have incentives to reduce private losses or to correct for distributional consequence, they will have inducements to provide compensation for losses from state earthquake prediction activity. Because of states being unrestricted in prediction activity, other governments will be less inclined to become involved in earthquake prediction.	If uncompensated losses exist, other governments may engage in relief activities. If compensation by state restrains its prediction activity, other governments may be induced to become involved in prediction.	Other governments are not likely to engage in relief unless state-paid damages are well short of compensatory. Because state prediction may be restrained, other governments may become involved in prediction.
DISTRIBUTIONAL IMPACTS OF LEGISLATIVE ACTION		Although absolute losses are likely to be higher for wealthy and middle-income individuals, the impact will probably be relatively greater on low-income individuals who are unable to absorb even small losses.	Losses may fall more heavily on low-income or high-income individuals depending upon the nature of the immunity. The waiver may be manipulated for distributional purposes, although there will be some constitutional constraints. Unless legal assistance is provided low-income individuals may be prevented from seeking relief.	A general waiver is likely to magnify distributional inequities due to the high cost of initiating suit to recover damages. This impact will be minimized by the provision of legal assistance to the poor.

TO LIABILITY FOR STATE INVOLVEMENT IN EARTHQUAKE PREDICTION

<i>DIRECT LEGISLATIVE OR ADMINISTRATIVE RELIEF</i>			
<i>Affirmative declaration of state liability</i>	<i>Legislative compensation for existing injury</i>	<i>Authorization for administrative relief of prospective</i>	<i>Statutory schedule of relief for prospective injury</i>
Common law doctrines would presumably be inapplicable. The magnitude of state liability would depend upon judicial interpretation of the intended application of the declaration of state liability. The state cost is potentially high.	The magnitude of state liability is dependent entirely upon the losses compensated and the size of the legislative appropriations.	The magnitude of state liability will depend upon the legislative definition of administrative discretion and the level of appropriation. The state cost is potentially high.	The magnitude of state liability will depend upon the injuries for which compensation is provided and the level of compensation to be paid. The cost to the state is potentially high.
Common law doctrines would be inapplicable. The magnitude of private loss would depend upon judicial interpretation of the intended scope and level of private recovery. Private loss is potentially low or even negative if collateral source recovery is not prohibited.	The magnitude of private loss is dependent upon the losses compensated and the level of the legislative appropriation.	The magnitude of private loss will depend upon the extent of administration discretion and the level of appropriation. The private losses are potentially low for some or all individuals. Collateral source recovery may result in a net gain.	The magnitude of private loss will depend upon what injuries are compensated and the level of compensation to be paid. Private losses are potentially low for some or all individuals. Collateral source recovery may result in a net gain.
Administrative costs will be limited to administration of judicially awarded relief. The affirmative declaration of liability may encourage private suits leading to very high litigation costs.	Transaction costs are potentially very high. Costs will result from the legislative process and the associated political transactions. Administrative costs will result from determination of eligibility for relief and administration of that relief.	Administrative costs will result from the need to determine eligibility for relief and from the administration of the relief. These costs are potentially high.	Assuming administrative efficiency, transaction costs should be moderate in comparison to more discretionary administrative compensation schemes. Eligibility and level of relief should be easily determined.
Private litigation costs will exist with respect to each individual claim and will be very high in the aggregate due to the incentive to litigate which is likely to flow from an affirmative declaration of liability.	Private costs associated with influencing the legislature are potentially very high. Private costs associated with relief administration are potentially low depending upon the burdens placed upon the applicants for relief.	Some political costs may result if the administrative determination is subject to influence. Private costs associated with relief administration are potentially low depending upon the burdens placed upon the applicants for relief.	Private costs should be relatively low depending upon the burden placed upon the applicants for relief.
State earthquake prediction activities are likely to be severely restrained by an affirmative declaration of government liability for harm resulting from those activities. State opposition to liability will be difficult and damage awards are likely to be high.	If post-injury legislative relief is anticipated or has been experienced, it will probably constrain state earthquake prediction activity, particularly if the magnitude of past relief has been large.	The impact of post-injury administrative relief on state earthquake prediction activity will depend upon the extent of administrative discretion and the past or anticipated level of legislative appropriation.	Because of the certainty associated with a schedule of relief benefits, states will be able to anticipate the compensation costs associated with earthquake prediction and will therefore be less constrained than in a situation of less certainty.
An affirmative declaration of state liability will induce private action which is high risk in relation to possible injury from state earthquake prediction activity. Whether the inducement remains will depend upon judicial application of the statute and the level of damages awarded.	Private individuals will experience a high level of uncertainty since compensation for losses resulting from state earthquake prediction activity will always be a political issue. They will also have an incentive to invest in influencing the legislative decision.	Private individuals will have increasing certainty as they gain experience with the administrative relief process. The degree of certainty will be impacted by the level of administrative discretion allowed by the statute and by the extent to which the administrative decisionmaking varies over time.	Private individuals will have a high degree of certainty and will act with respect to state earthquake prediction activity in a way which maximizes private gains and minimizes private losses.
Other governments are not likely to engage in relief unless court ordered damages to be paid by state are not compensatory. Because state prediction will be restrained, other governments are likely to engage in prediction activities.	The politics of state compensation and of compensation by other governments will be related due to overlapping constituencies. If state prediction activity is restrained, there will be incentives for prediction by other governments.	Relief by other governments will depend upon the adequacy of state relief. Other governments will have incentives to engage in earthquake prediction to the extent the state is constrained by the costs of relief.	Other governments will know in advance the adequacy of state compensation and can act accordingly. Reduced constraints on state prediction activity will reduce incentives for other governments to engage in such activity.
An affirmative declaration of liability will encourage suits for damages which will be brought by those financially able to do so. The distributional result is likely to be greater inequity.	Legislative compensation could have the express objective of relieving distributional inequity although political pressures will be brought by those who can afford to engage in lobbying which could lead to legislative action resulting in greater inequity.	Because of the time lag between legislative authorization and relief administration, and because of the non-political (to a degree) nature of the administrative process, the possibility for relieving distributional inequity is good.	Because of the anticipatory nature of the relief, vested interests will have less incentive to anticipate their own possible losses. However, the specificity of the schedule will encourage lobbying. The distributed impact will depend upon the injuries for which compensation is provided.